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Criteria for Municipal Solid Waste Landfills (40 CFR Part 258). Subtitle D of Resource Conservation and Recovery Act (RCRA) Location Restrictions (Subpart B)

NUS Corp., Rockville, MD

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In August 1988, the U.S. Environmental Protection Agency proposed Solid Waste Disposal Facilities Criteria (40 CFR Part 258) for municipal solid waste landfills. This background document provides the technical support for Subpart "B" - Location Restrictions of Part 258.

This document contains a discussion of the legislative and regulatory background for understanding the current status of Subtitle D. A discussion of other Federal laws, besides the Resource Conservation and Recovery Act (RCRA), that impact the siting of municipal waste landfills is also presented. The document also presents detailed information on the revised location restrictions. The location restrictions include the following: airport safety, floodplains, wetlands, fault areas, seismic impact areas, and unstable areas.

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(SUBPART B)

"CRITERIA FOR MUNICIPAL SOLID WASTE LANDFILLS"
(40 CFR PART 258)

SUBTITLE D OF RESOURCE CONSERVATION AND
RECOVERY ACT (RCRA)

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

JULY 1988

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I. INTRODUCTION

The 1984 Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) directed EPA to revise the "Criteria for Classification of Solid Waste Disposal Facilities and Practices" (40 CFR Part 257) for facilities that may receive household hazardous waste (HHW) or hazardous waste from small quantity generators (SQGs). Such revisions shall be those necessary to protect human health and the environment and may take into account the "practicable capability" of facilities to implement the Criteria. At a minimum, the revisions should require ground-water monitoring as necessary to detect contamination, establish location standards for new or existing facilities, and provide for corrective action as appropriate.

In carrying out this mandate, EPA has undertaken efforts to revise the current Criteria. EPA is initially limiting the Criteria revisions to municipal solid waste landfills (MSWLFs) because these are the only facilities for which the Agency has complete and reliable data, as discussed in the Revised Final Draft Report to Congress: Solid Waste Disposal in the United States, Volume I and II [EPA, April 1988]. The rationale for this choice is further discussed in the Background Document for Options Selection [EPA, September 1986a].

Section II of this document provides a discussion on the legislative and regulatory background and their status. Section III addresses other Federal laws that impact the design, operation, and location of MSWLFs. Section IV contains detailed information on the development of the standards addressing restricted locations. Additional background documents have been developed to support other aspects of the revised Criteria.

II. BACKGROUND

This section provides the legislative and regulatory background for understanding the current status of the Subtitle D program. Beginning with the legislation establishing Subtitle D of the Resource Conservation and Recovery Act of 1976, the section briefly reviews Federal and State implementation efforts from 1978 up to 1981 when Federal attention turned to the hazardous waste program and Federal funding to State Subtitle D programs ended. The section then outlines the new Subtitle D provisions contained in the Hazardous and Solid Waste Amendments of 1984 and describes EPA's major activities implementing these provisions.

A. SUBTITLE D OF THE RESOURCE CONSERVATION AND RECOVERY ACT

With the passage of the Resource Conservation and Recovery Act (RCRA) of 1976, Congress significantly expanded the Federal role in controlling the management of waste materials in the United States. Subtitle C of RCRA required EPA to establish a comprehensive regulatory program to ensure proper management of hazardous waste. Subtitle D required EPA to provide technical assistance to the States and to develop Federal criteria for controlling solid waste management practices, and authorized Federal financial assistance to help the States accomplish this effort.

Subtitle D of RCRA established a cooperative framework for involving Federal, State and local governments in dealing with solid waste problems. The Federal role in this arrangement is to provide technical assistance to States and regions for planning and developing environmentally sound waste management practices and to furnish financial assistance to enable States to implement these measures. The actual planning and implementation of solid waste programs under Subtitle D, however, remain State and local functions. The primary provisions of Subtitle D, that are discussed later in this section, include:

- Section 4002 -- Federal Guidelines for State Plans.
- Section 4004 -- Criteria for Solid Waste Disposal Facilities.
- Section 4005 -- Prohibition of Open Dumps.

In addition to these technical provisions, Section 4008 of Subtitle D authorizes EPA to provide grants to States for development and implementation of solid waste management plans, resource recovery programs, and resource conservation programs.

B. IMPLEMENTATION OF SUBTITLE D

In a series of rulemakings beginning in 1978, EPA began the process of implementing the provisions of Subtitle D. The Section 4002 guidelines for State plans were completed in 1979, and EPA began reviewing plans submitted by States and providing grants to States for program planning and implementation. The Criteria for classifying solid waste disposal facilities also were finalized in 1979. These Criteria were used by the States to classify facilities as either "sanitary landfills" or "open dumps". EPA published the first inventory of open dumps in 1981. In that year, however, Federal funding for State nonhazardous waste programs that implemented and enforced the Criteria was terminated.

Guidelines for State Solid Waste Management Plans

Pursuant to RCRA Section 4002(b), EPA promulgated guidelines for the development and implementation of solid waste management plans on July 31, 1979 [44 FR 45066]. These guidelines identify the minimum statutory requirements that State plans must address and also deal with a full range of solid waste management, materials conservation, and resource recovery issues.

As the centerpiece of the Subtitle D program, the State solid waste management plan serves a critical function. It is through this plan that each State identifies a general strategy for protecting public health and the environment from adverse effects associated with solid waste disposal, specifies efforts for encouraging resource recovery and resource conservation, and formulates plans for providing adequate disposal capacity within the State. The plan also describes the institutional arrangements that the State will use to implement its solid waste management program.

Under Subtitle D, EPA reviews and approves State plans that meet the Agency guidelines. As of June, 1988, EPA has fully approved 25 States' solid waste management plans and partially approved another six. EPA also had authority to provide grants to States to assist them in development and implementation of their plans. However, EPA discontinued those solid waste grants in 1981 when the focus of the Federal program turned to hazardous waste.

Federal Criteria for Solid Waste Disposal Facilities

Pursuant to RCRA Sections 4004(a) and 1008(a)(3), EPA proposed Criteria for classifying solid waste disposal facilities on February 6, 1978 (43 FR 4942). Final Criteria were promulgated on September 13, 1979, and minor modifications were issued in September 1981 These Criteria are entitled the "Criteria for the Classification of Solid Waste Disposal Facilities and Practices", and are found at 40 CFR Part 257. They provide minimum national standards for any solid waste disposal facility or practice, including landfills, surface impoundments, land application units, and waste piles. The Criteria include general environmental performance standards that establish the level of protection necessary to ensure that "no reasonable probability of adverse effects on health or the environment" will result from operation of the facility. A facility that meets these Criteria is classified as a "sanitary landfill"; a facility in violation is classified as an "open dump" and must be upgraded or closed.

Implementation and enforcement of these Subtitle D Criteria are the responsibility of State and local governments. In addition, private citizens may use RCRA's citizen suit provisions to bring actions in Federal court to enforce the Criteria against violators.

C. SUBTITLE D PROVISIONS OF HAZARDOUS AND SOLID WASTE AMENDMENTS OF 1984

On November 8, 1984, the Hazardous and Solid Waste Amendments of 1984 (HSWA) were passed. These amendments affected virtually every part of the RCRA program, including solid waste management.

Section 302 of these Amendments directed EPA to study and revise the Criteria, as well as examine the need for additional enforcement authorities. This Section states that EPA must "conduct a study of the extent to which the (Criteria)...applicable to solid waste management and disposal facilities, including, but not limited to landfills and surface impoundments, are adequate to protect human health and the environment from ground water contamination." This study, which must be completed and delivered to Congress in report form "shall also include recommendations with respect to any additional enforcement authorities which the administrator, in consultation with the attorney general, deems necessary" to protect ground water.

In addition to the study, Section 302 of HSWA requires EPA to promulgate revised Subtitle D Criteria for facilities that receive hazardous household waste or hazardous waste from small quantity generators. HSWA states that such revisions "shall be those necessary to protect human health and the environment and may take into account the practicable capability of...facilities [to implement the Criteria]. At a minimum, [the] revisions...should require ground- water monitoring as necessary to detect contamination, establish criteria for the acceptable location of new or existing facilities, and provide for corrective action as appropriate."

HSWA also requires each State to establish by November 8, 1987, a permit program or other system of prior approval for facilities receiving small amounts of hazardous waste. This permit program is meant to ensure that such facilities are in compliance with the Criteria. Within 18 months of EPA's promulgation of the revised Criteria, each State must modify its permit program or alternate system accordingly. If a State fails to develop and implement an appropriate permit program, or other system of prior approval, EPA is given the authority to enforce the Criteria at facilities accepting household hazardous waste or small quantity generator waste.

D. SUBTITLE D STUDY AND CRITERIA REVISIONS

EPA is currently proceeding with implementation of HSWA's Subtitle D requirements, including the completion of the Subtitle D study and the development of the Criteria revisions. The major objectives of the Subtitle D study are to identify, characterize, and evaluate the environmental and human health impact of all solid waste disposal facilities and to determine the adequacy of the current regulatory program and Subtitle D enforcement authorities. The Subtitle D study was conducted in two phases. During Phase I of the study that was completed in October 1986, EPA used existing information gathered from the literature, States, EPA files, voluntary submissions from facility owners or operators, and any other available sources to address the objectives of the study.

In Phase II, which is still proceeding, EPA will concentrate on filling the information gaps identified during Phase I through collection of additional existing data and original data collection efforts. Phase II will result in the completion of the Subtitle D study report and its submission to Congress.

At the same time, EPA is developing changes to the Subtitle D Criteria for facilities that receive household hazardous waste and small quantity generator hazardous waste. This document provides detailed background data and information that was used to develop and evaluate the location-based design criteria for new and existing municipal solid waste landfills.

III. CONSIDERATION OF OTHER FEDERAL LAWS

Numerous other Federal laws and regulations must be considered when siting, designing, constructing and operating MSWLFs. This section contains a short description of the Federal statutes that are especially pertinent to facility siting and operation. These statutes have been highlighted because: (1) they contain specific requirements that must be considered prior to issuance of a license or permit, and (2) they must be considered as part of the hazardous waste facility permit application process under 40 CFR Part 270.3. Although the Subtitle D Criteria do not include a permitting program, as in Subtitle C, the Agency believes it is important to bring these particular statutes to the attention of the owner or operator of MSWLFs. However, it is the ultimate responsibility of the owner or operator to comply with the requirements of all applicable statutes.

The proposed Criteria do not impose any requirements beyond those imposed by the terms of the statutes. In general, the statutes are independent of RCRA and are enforceable by the appropriate Federal agency or State. Other statutes in addition to the ones presented here may require compliance and should be considered by the owner or operator.

National Historic Preservation Act of 1966, as Amended (16 USC Sections 470 et. seq.)

The National Historic Preservation Act established the National Register of Historic Places, created the Advisory Council on Historic Preservation and the State Historic Preservation Programs, and provides Federal funds for the preservation of historic properties.

Section 106 of the Act and implementing regulations (36 CFR Part 800) require Federal agencies (the Regional Administrator) to evaluate the impact of licensed activities on properties listed or eligible for listing in the National Register of Historic Places, and to adopt measures, when feasible, to mitigate any potential adverse effects where determined necessary by this evaluation. In addition, this evaluation must be implemented in cooperation with the State Historic

Preservation Officers and, when appropriate, in consultation with the Advisory Council on Historic Preservation.

Although EPA is not issuing permits under the Subtitle D Criteria, the owner or operator of a MSWLF should be aware of the properties listed on the National Register of Historic Properties and should consult with the State Historic Preservation Office to ensure that the property to be used for a MSWLF does not impact those listed as historic properties.

The Endangered Species Act (16 USC Sections 1531 et seq.)

The Endangered Species Act provides for the designation and protection of wildlife, fish and plant species that are in danger of becoming extinct, and to conserve the ecosystems on which such species depend. The Act defines an endangered species as any species, other than a recognized insect pest, which is in danger of becoming extinct throughout all or a significant portion of its range. A threatened species is one which is likely to become endangered in the foreseeable future. The Act makes it illegal for any individual to kill, collect, remove, harass, import, or export an endangered or threatened species without a permit from the Secretary of Interior.

In addition, Section 7 of the Act requires the Regional Administrator to ensure, in consultation with the Secretary of Interior, that any action authorized, funded or carried out by EPA is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its critical habitat. Because the Subtitle D criteria is not a federally administered permit program, it will be the responsibility of the owner or operator of a MSWLF to consult with and obtain a permit from the Secretary of Interior if the construction or operation of the MSWLF may potentially impact any endangered or threatened species or its critical habitat.

The Coastal Zone Management Act (16 USC Sections 1451 et seq.)

The Coastal Zone Management Act was enacted to provide for comprehensive and coordinated planning for the protection and beneficial use of coastal resources. Objectives include: (1) protection of coastal resources by fostering State management of coastal development and preparation of State management programs, and (2) providing improved intergovernmental coordination in coastal zone decision making.

Section 307(c) of the Act prohibits EPA from issuing a license or permit for an activity affecting land or water use in the coastal zone until the applicant certifies that the proposed activity complies with the State coastal management program, and the State or its designated agency concurs with the certification (or the Secretary of Commerce overrides the State's nonconcurrence). Owners or operators should, where necessary, consult with the appropriate State agency administering the State coastal management program to ensure that the proposed MSWLF will not affect the State's coastal zone.

The Wild and Scenic Rivers Act (16 USC Sections 1271 et seq.)

The purpose of this Act was to establish a national wild and scenic rivers system that includes selected rivers of the nation that, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values. Under this Act, selected rivers are to be preserved in their free-flowing condition and are to be protected along with their immediate environments for the benefit and enjoyment of present and future generations.

Section 7 of the Act prohibits Federal agencies from assisting, by license or otherwise, the construction of any water resources project that would have a direct, adverse effect on a national wild and scenic river or its immediate environment. When siting the location of a new MSWLF, the owner or operator of the MSWLF should ensure the protection of wild and scenic rivers in accordance with this Act.

The Fish and Wildlife Coordination Act (16 USC Sections 661 et seq.)

The purpose of the Fish and Wildlife Coordination Act is to assure that fish and wildlife resources receive equal consideration with other values in the planning of development projects affecting water resources. The legislation was enacted in recognition of the fact that water-related project goals, such as flood control, irrigation, navigation, and hydroelectric power may, at times, conflict with the goal of conserving fish and wildlife resources.

This Act requires the Regional Administrator to consult with the U.S. Fish and Wildlife Service and the appropriate State Agency administering the wildlife resources in the affected State prior to issuing license or permit for an activity involving the impoundment (with certain exemptions), diversion, or other control or modification of any stream or body of water.

The owner or operator of MSWLFs should be aware of this Act and should consult with the appropriate State agency prior to the siting or construction of a MSWLF that may impact fish and wildlife resources.

The Clean Water Act (33 USC Sections 1251 et seq.)

The Federal Water Pollution Control Act (Clean Water Act) established a comprehensive Federal/State framework for controlling the introduction of pollutants into the Nation's water. Several provisions of this Act may be applicable to the siting and operation of a MSWLF. These include the requirement, under Section 402 of the Act, to obtain and comply with a National Pollutant Discharge Elimination System (NPDES) permit for point source discharges into waters of the United States and the requirement under Section 208 of the Act to comply with an approved area-wide or State-wide water quality management plan for non-point source discharges. As these requirements may be relevant to the operation of MSWLFs in certain situations, specific criteria referring to these two aspects of the Act have been included under the surface water section of the Criteria (see Background Document for Subpart C: Surface Water for more details).

Section 404 of the Act requires permits for any activities involving the discharge of dredged or fill materials. This Section is relevant to MSWLFs that may be sited in areas, particularly wetlands, involving dredge and fill activities. It is the responsibility of the owner or operator to obtain the required permits. The wetlands Section contained in this document, Section IV.C, discusses this topic in more detail. EPA believes these Sections of the Act are important for protecting human health and the environment and are relevant to siting and operating MSWLFs.

IV. DEVELOPMENT OF SPECIAL RESTRICTIONS

Several considerations must be evaluated when siting a MSWLF. These include sites in the vicinity of airports, the 100-year floodplains, wetlands, fault areas, seismic impact zones and unstable areas. Standards for each of these types of locations have been established under Subpart B of the revised Criteria.

The following sections discuss the potential impacts associated with the six types of locations and present the rationale used to develop the standard or criteria that EPA has chosen to prevent adverse impacts to human health or the environment.

A. AIRPORT SAFETY

An aircraft/bird strike can be defined as any contact between a moving aircraft and a bird (or group of birds). The results of such collisions range in severity from dents or holes in the aircraft structure to aircraft accidents and loss of life. Birds can cause aircraft accidents by penetrating windshields and disabling crew members or by impact and deformation of the turbine engines or other aircraft parts [Solman, 1973] Bird strikes on windshields may crack, shatter, or completely destroy a panel, exposing pilots to flying pieces of glass, bird debris, and high wind velocity. In addition, bird strikes to windshields may startle pilots, impair their judgement, or distract their attention [Blokpoel, 1976].

The majority of bird strikes occur on the forward facing parts of the aircraft. Wide-bodied aircraft have a higher risk of colliding with birds because they have large frontal areas and large air intakes [Blokpoel, 1976]. Statistics for military aviation in the United States in 1973 indicate the following distribution of bird strikes by aircraft part struck [Blokpoel, 1976]:

Aircraft Part	Percentage of Bird Strikes
Wing	27.8
Tail	1.6
Nose	1.9
Windshield	5.5
Engine	32.8
Landing Gear	2.7
Other	17.7

Because of the high velocities of aircraft, a bird strike can create an enormous impact. A four pound bird (such as a mallard duck) hit by an aircraft at 300 miles per hour causes a saucer-sized impact of 15 tons. For a collision at 600 miles per hour, the force of this impact would be nearly 60 tons [Solman, 1973]. Statistics for civil aviation in the United Kingdom and the Soviet Union indicate that over two-thirds of all bird strikes occur at speeds of 92 to 184 miles per hour [Blokpoel, 1976].

Bird strikes pose a greater hazard to jet aircraft than to propellor aircraft [U.S. Department of Interior, 1978]. The rotating blades of a propellor aircraft tend to protect the piston engine, while turbine engines are usually exposed to direct bird ingestion, that can deform or destroy the rotor and stator blades of the engine's compressor [Blokpoel, 1976].

Damage to aircraft and loss of life due to bird/aircraft collisions have been documented since the beginning of aviation. A summary of serious bird strikes in civil aviation is presented in Attachment 1 (Appendix A). Between 1960 and 1972, bird strikes caused accidents resulting in more than 100 deaths and costing more than $100,000,000 in North America. In the United States, commercial losses due to bird strikes are estimated at several million dollars per year, and Air Force annual losses amount to about ten million dollars [Forsythe, 1974]. Two examples of accidents resulting from bird strikes at airports located near landfills are described below [Solman, 1973].

> On December 15, 1972 a Northwest Airlines Boeing 747 with 149 passengers and 11 crew on board ingested one or more gulls into one engine just after lift off from Miami Airport. In the following emergency landing the aircraft received further damage when the nosewheel assembly collapsed after striking an obstacle after the aircraft ran off the wet runway. Four passengers received minor injuries. A landfill with edible garbage exposed attracts several thousand gulls to an area near the airport. The authority which operates the airport also operates the landfill which is the major gull attraction in the area.
>
> A Learjet Aircraft taking off from De Kalb-Peachtree Airport at Atlanta, Georgia on February 26, 1973 ingested starlings into both engines and crashed killing the 7 persons in it. A landfill on the airport attracted the birds. An appropriate Federal agency had requested the closure of the landfill for more than a year before the crash. A U.S. District judge in March ordered the airport closed until May 1 to all turbine-powered aircraft, until the landfill could be rendered unattractive to birds. The airport handles about 200,000 operations per year.

The Federal Aviation Administration (FAA) has identified 27 airports in the United States known to have a solid waste related bird hazard. These airports are listed in Attachment 2 (Appendix A).

On October 16, 1974 the FAA issued Order 5200.5 in response to the increasing problem of bird strikes at airports located near municipal solid waste disposal facilities (see Attachment 3 in Appendix A). The Order states that landfills located within 10,000 feet of any runway used by turbojet aircraft, or within 5,000 feet of any runway used only by piston type aircraft, should be closed. It also recommends the closing of any landfill located such that it places the airport runways or aircraft flight patterns between bird feeding, water, or roosting areas [FAA, 1974].

Several factors affect the degree to which birds are attracted to the site. One study estimated that open dumps attract 50 percent more birds than sanitary landfills [Forsythe, 1974]. Despite efforts at vector control such as the application of cover material, birds continue to be attracted to municipal solid waste disposal facilities [43 FR 4951, February 6, 1978]. One study done at a landfill in Southern California found that the largest group of gulls arrived at the landfill early in the morning to feed on the edible waste that was not completely covered the night before [Ultrasystems, Inc., 1977]. The same study found that birds were less likely to forage at the working face if it was located in a deep pit rather than at an open, above ground location. The researchers reasoned that the birds were less likely to forage in an area where their vision was sharply limited.

The location of bird roosting and watering areas in the vicinity of airports have also been found to increase bird attraction [Ultrasystems, Inc., 1977; FAA, 1976]. Bird strike hazards are often created when birds must cross the airport or its flight paths when they travel to and from their roosting grounds and the landfill in the morning and evening [Solman, 1973; Forsythe, 1974]. The lack of disturbance at the landfill, particularly from humans and dogs, has also been found to be a factor in bird attraction [Forsythe, 1974].

Daily, seasonal, and operational patterns of bird strikes have been observed at airports. It is estimated that 75 percent of bird/aircraft collisions occur during takeoff and landing [Blokpoel, 1976]. Bird strikes during takeoff and landing pose a serious hazard to aircraft because any sudden loss of power or control during this time can be particularly dangerous [Ultrasystems, Inc., 1977].

Over 62 percent of all bird strikes occur below altitudes of 500 feet [FAA, 1974]. Air Force statistics for 1972 indicate that 86 percent of bird strikes occurred below 2,000 feet, and 93 percent occurred below 3,000 feet [Blokpoel, 1976]. Impact altitude statistics compiled by the FAA (Attachment 4, Appendix A) are in agreement with these percentages.

Air Force statistics indicate that 66 percent of bird strikes occur during the day, corresponding to the time that most birds are active [Forsythe, 1974]. Seasonal variations in bird strikes have also been observed as the Air Force reports an increase in bird strike incidents during the spring and fall [Blokpoel, 1976]. Some MSWLFs may only pose bird strike hazards on a seasonal basis, due to bird migratory patterns.

It is estimated that gulls are involved in about half of all bird/aircraft collisions in the United States [Solman, 1973]. One author found that gulls "are good gliders, but they cannot accelerate quickly to get out of the way of approaching aircraft. Furthermore, they sometimes try to outfly the airplane rather than dodge to the side" [Blokpoel, 1976]. A single gull can destroy the engine on a medium or large jet [Solman, 1973].

In the southeast and the gulf coast of the United States the two most common species of gulls found at landfills are the Herring and the Ring-billed Gull (Laurus delawarensis). In the northeastern United States the two principal refuse feeding species are the Herring and the Great Black-backed Gull (Laurus marinus) [Forsythe, 1974]. In central and southern California, several refuse feeding gulls have been observed, including the Glaucous-winged (Laurus glaucescens), Western (Laurus occidentalis), California (Laurus californicus), Ring-billed (Laurus delawarensis), and the Herring Gull [Forsythe, 1974; Ultrasystems, Inc., 1977].

A disproportionate number of immature birds are usually observed feeding at the disposal sites [Forsythe, 1974]. There is a tendency for immature birds to concentrate around dumps and other artificial food supplies, while adults feed mainly on natural food sources. This may be due to exclusion of the young from more natural feeding areas by adults, or inexperience in food procuring by young birds [Forsythe, 1974].

Although gulls are the species involved in the majority of bird/aircraft collisions in the United States, collisions with a wide variety of other birds have been documented. According to one author, "birds of prey are reported to have attacked gliders and aircraft, whereas waterfowl usually try to avoid airplanes. Birds that usually spend their lives among the trees, such as woodpeckers, are not likely to be involved in a strike unless they are migrating" [Blokpoel, 1976]. Researchers have conducted a survey of the bird species most commonly observed adjacent to one airport in the northeast United States. The survey results are presented in Attachment 5 (Appendix A).

Because each airport presents a unique topographical and ecological environment, uniform national standards regarding landfills located near airports would not be appropriate. Each airport environment must be considered individually to assess the bird strike hazard for that area. For this reason, EPA has established a broad, performance based requirement for minimizing bird strike hazards posed by MSWLFs. As with the standards regulating solid waste disposal facilities (40 CFR Part 257) the requirements for MSWLFs adopt the minimum distances from airport runways specified in FAA Order 5200.5. As mentioned before, 62 percent of all bird strikes occur below altitudes of 500 feet, and aircraft are generally below this altitude within the distances specified in the FAA Order [44 FR 53459, September 13, 1979]. EPA believes this restriction will prevent most bird/aircraft collisions caused by the proximity of MSWLFs to airports, while not placing an undue burden on the regulated community. Eleven States and territories specify the same distance as the proposed EPA requirement, and two specify more stringent requirements. States' requirements for locating MSWLFs in the vicinity of airports are presented in Attachment 6 (Appendix A).

EPA has not specified techniques or practices to ensure that MSWLFs located within the specified distances do not pose a bird hazard to aircraft. However, EPA's guidance document, Classifying Solid Waste Disposal Facilities [EPA, SW-828, 1980] presents a four step process to determine if such a hazard exists. A flow chart describing this process is presented in Attachment 7 in Appendix A.

The first step in the process is to determine the distance from the runway to the solid waste boundary of the MSWLF. Distance is measured radially from the end of the runway to the solid waste boundary, as illustrated in Attachment 8 (Appendix A). The determination of distance can be made using recent United States Geological Survey (USGS) 7½ minute maps, scale aerial photos of the area, or plot plans of the facility and the surrounding area [EPA, SW-828, 1980].

The second step is to determine if the facility accepts wastes that may be attractive to birds. These wastes include, but are not limited to, the following [EPA, SW-828, 1980]:

- Residential wastes,
- Food wastes, food marketing wastes, food processing wastes, such as, agricultural wastes, or food canning wastes,
- Sewage sludge,
- Septic tank pumpings,
- Animal manures,
- Animal carcasses, and
- Similar putrescible wastes.

MSWLFs receiving only the following types of waste are not considered to be attractive to birds [EPA, SW-828, 1980]:

- Fill dirt,
- Clean construction and demolition wastes,
- Inorganic wastes such as ash, metals, plastics, glass, ceramic, rubber, mineral, or chemical wastes,

- Bulky wastes such as large auto parts, tires, stoves, and refrigerators, and

- Similar non-putrescible wastes.

State discretion should be used for MSWLFs receiving only [EPA, SW-828, 1980]:

- Land clearing debris,

- Industrial wastes such as leather, cartons, paper, pulp, lumber, sawdust, bark, and

- Processed wastes such as incinerator residue, shredded, or baled wastes.

Once the distance of the facility from the airport and the types of waste received have been determined, EPA recommends prioritizing the facilities according to their potential to pose a bird hazard. Criteria for prioritization are presented below [EPA, SW-828, 1980]:

1. First Priority - Facilities identified by the FAA as having a solid waste related bird hazard (Attachment 2, Appendix A).

2. Second Priority - Facilities located within the specified distances (10,000 feet for turbine aircraft and 5,000 feet for piston type aircraft), and identified by the FAA as having a bird hazard to aircraft (not necessarily related to solid waste disposal) (Attachment 9, Appendix A).

3. Third Priority - Facilities within the specified distances and known to a State solid waste agency as having a bird hazard to aircraft. Identification of such facilities can be made through records of [EPA, SW-828, 1980]:

    - Previous complaints,

    - Past inspection reports,

    - Previous study or knowledge of a potential problem, and by contacting or referring to:

- Airport owners/operators,
- State aviation office,
- U.S. Fish and Wildlife Service,
- U.S. EPA Regional Offices,
- State Wildlife offices,
- Bird hazard specialists, and
- Airman's Information Manual, Part 3A (published by the National Flight Data Center).

4. Lowest Priority - Facilities located within the specified distances that have not previously been eliminated or ranked.

Evaluations of bird hazards posed to aircraft should be made according to priority ranking. Evaluations can be made on the basis of the following considerations [EPA, SW-828, 1980]:

- Determination of whether the bird populations at the facility are higher than natural populations in the area, for each species;
- Contact with the airport to determine if there has been a history of bird strikes;
- Establishment of flight patterns of bird species through visual observation, radar tracings of birds, marking of birds, or examination of the stomach contents of dead birds in the airport area to evidence previous feeding at the disposal facility;

- Identification of other topographic features in the vicinity of the airport capable of attracting birds, such as:
  - Crop land,
  - Water - especially standing bodies of water and wetlands,
  - Vegetation, especially forests,
  - Open areas - fields (especially recently disturbed), grasses, golf courses,
  - Animal feeding operations, and
  - Solid waste handling at the airport; and
- Identification of bird populations in these areas and comparison with bird populations at the landfill and the airport.

Once the populations and behaviors of the bird species at the landfill, airport, and the surrounding areas have been determined, an evaluation of the bird strike hazard posed by the presence of the landfill can be made.

B. FLOODPLAINS

Executive Order (E.O.) 11988, signed into effect on May 24, 1977, requires that each Federal agency "shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impacts of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities" (see Attachment 10, Appendix A). EPA addressed E.O. 11988 in the Criteria for Classification of Solid Waste Disposal Facilities [44 FR 53438, September 13, 1979] by requiring that "facilities or practices in 100-year floodplains shall not restrict the flow of the base flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human life, wildlife, or land or water resources"

[40 CFR Part 257.3-1]. EPA has used an almost identical requirement in its rule for MSWLFs.

Attachment 11 (Appendix A) shows that large regions of the United States are susceptible to flooding. Siting facilities in these regions can pose threats to human health and the environment in a variety of ways. Flooding can cause erosion of landfill cover material, allowing increased infiltration of water. Increased water content in the landfill can lead to increased leachate production, with increased potential for surface and ground-water contamination. The large water volumes and high flow velocity associated with floods can cause washout of wastes, that can lead to surface and ground-water contamination. Flooding can cause infiltration through the final cover or through joints between covers and liners. Wave action and flowing water can destroy containment structures and levees, and underseepage can weaken them. Weakened containment structures can increase the vulnerability of MSWLFs during future flooding activity. Finally, flooding can relocate stream channels in the vicinity of the MSWLF, causing or worsening run- on to the working face of the facility [MITRE Corp., 1980; MRI, 1984]

Several factors affect the extent of damage sustained by a MSWLF during a flood. These factors are discussed briefly below.

- Location - Facilities located in the middle of a 100-year floodplain are more likely to be inundated from all sides by the 100-year flood, while facilities located on the edge of the 100-year floodplain are more likely to have only one side exposed to the flood source [MITRE Corp., 1980].

- Proximity of other structures - Close proximity of other structures to MSWLFs will increase floodwater elevations and can increase flow velocities downstream. Nearby structures will expose the MSWLF to channeling effects, and the MSWLF can cause or exacerbate a channel effect on structures downstream from the facility [MITRE Corp., 1980].

- Flood depth - Depth of the floodwaters determines the strength of the hydrostatic forces in effect during the flood. Vertical loading can cause uplift and lateral displacement of wastes, and is directly related to leachate generation. Horizontal loading can cause washout of wastes [MRI, 1984].

- Floodwater Velocity - Floodwater velocity affects the momentum and damage potential of the floodwaters. Increasing floodwater velocity tends to increase erosion of cover material and cause damage to MSWLF structures. Floodwater velocity also affects the momentum and damage potential of the debris and sediment carried by the flood [MRI, 1984].

- Duration of flooding - The duration of a flood affects the degree of saturation of soils and building materials, contributing to their weakness, and increases the magnitude of leachate generation and leachate seeps [MRI, 1984].

- Speed of flood's onset - Speed of a flood's onset is significant because it is equivalent to the warning time that MSWLF personnel will have to initiate emergency procedures to prevent washout of waste.

- Ground-water level - Ground-water level at the time of flooding is an important factor in determining the impact of the flood on the integrity of MSWLF structures.

- Sediment and debris content of flood - In addition to causing impact damage, sediment and debris content of a flood can bury waste under sediment. Hidden from view, these wastes can potentially endanger human health and the environment.

- Chemical properties of MSWLF waste - The chemical characteristics of the wastes in the MSWLF can affect their rate of dispersion upon washout from the landfill. According to one theory [MRI, 1984], hazardous chemical constituents that tend to be widely diluted and dispersed by the floodwaters cause the least adverse impacts on human health and the environment, while chemical constituents that remain concentrated in a small area will tend to cause greater impacts. Chemical properties that tend to increase the dispersion and dilution rates of hazardous constituents are [MRI, 1984]:

  - Water solubility,
  - Hydrolytic behavior and rate of volatilization,
  - Adsorption to suspended particulates and sediment, and
  - Biodegradation.

Types of Floods Occurring in 100-Year Floodplains

The magnitude of a flood is usually described by its statistical frequency of occurrence. According to MRI [1984] "The difference between 10, 100, and 500-year floodplains are most commonly differences in elevation and size of area inundated." The types of flood occurring in floodplains can be divided into two categories [MITRE Corp, 1980]:

- Flooding due to increased water elevation, and
- Coastal flooding.

The types of flooding due to increased water elevation or flow velocity include riverine floods, shallow floods, sheet runoff, ponding, lacustrine floods, and alluvial fan flooding. They are described briefly below [MITRE Corp., 1980].

- Riverine Floods - A riverine flood is the overflow of channelized water onto the surrounding floodplain. The velocity of a riverine flood can reach 30 feet per second, which is enough to washout the contents of a landfill. A riverine floodplain is illustrated in Attachment 12 (Appendix A).

- Shallow Floods - A shallow flood is an unconfined flood occurring in a topographic low area. Shallow floods include:

  - Sheet runoff, defined as "the broad unconfined downslope movement of water across gently sloping terrain," and

  - Ponding, defined as "the accumulation of runoff or flow in a depression that has no natural or man-made subterranean or rim outlets, culverts, or pumping stations."

- Lacustrine floods - A lacustrine flood is the increase in elevation of a lake due to seasonal and long-term water fluctuations.

- Alluvial fan flooding - Although flooding in an alluvial fan often follows the existing stream channels, unpredictable channel flow is common. MSWLF containment structures can be threatened when the direction of channelized flow, predicted to be parallel to dikes and levees, becomes perpendicular. A four to six foot per second flood velocity can be sufficient to disintegrate an earthen levee.

Coastal flooding is defined as flooding accompanied by wave action. Attachment 13 (Appendix A) illustrates a coastal floodplain. Facilities 500 feet inland can sustain severe damage during a 100-year storm, and even facilities 1,000 to 2,000 feet inland have been known to sustain damage, particularly if they were not elevated above the height of the incoming waves [MITRE Corp., 1980]. MSWLFs in such locations would be subject to daily tides, wave setup, tsunamis (tidal waves), storm surges, and wind surges. Because of State restrictions, it is unlikely that a MSWLF would be located on a coastal beach.

EPA has considered many factors in its choice of the 100-year floodplain as its regulatory standard. When EPA promulgated regulation for hazardous waste management facilities that are located in floodplains (40 CFR Part 264.18(b)), EPA considered use of the 500-year floodplain designation rather than the 100-year designation. The United States Water Resources Council (WRC) recommends restricting "critical actions," defined as "any activity for which even a slight chance of flooding would be too great" to the 500-year floodplain [43 FR 6030, February 10, 1978]. Initially, EPA decided that hazardous waste management facilities were "critical activities" and EPA proposed restricting their activity in the 500-year floodplain. However, due to almost unanimous opposition to the proposed standard [EPA (Wolfe), Memorandum dated June 27, 1983], EPA adopted the 100-year floodplain restriction in its final rule [46 FR 2847, January 12, 1981]. This decision was based on the following reasons [EPA (Wolfe), Memorandum dated June 27, 1983]:

- E.O. 11988 (Attachment 10, Appendix A) does not authorize regulation of activities in the 500-year floodplain.

- EPA did not have sufficient information to justify use of the 500-year floodplain designation.

- Maps of the 500-year floodplain were available for only very limited portions of the United States. A large financial burden would be placed on the regulated community to develop 500-year floodplain maps.

- Use of the 500-year floodplain designation would restrict large areas of the Unites States, such as the mid-Atlantic region, the southeast, and the Gulf States.

- The 100-year floodplain is the designation established for use by the U.S. Geological Survey, the Army Corps of Engineers, the Federal Insurance Administration, and many other agencies.

The Agency determined, therefore, that the 100-year floodplain was the appropriate regulatory standard for hazardous waste facilities. For the same reasons EPA also believes that the 100-year floodplain is the appropriate regulatory standard for MSWLFs. In addition, Attachment 14 (Appendix A) shows that 37 States and territories use the 100-year floodplain designation in their regulations.

The selection of the 100-year floodplain standard by the Agency is based on the analysis of present and past environmental impacts associated with waste management facilities wash-outs. The 100-year floodplain criteria poses the minimal environmental impact linked to the flooding of these facilities. The basis for this regulatory view can be justified by examining environmental impacts and supporting case studies in which the Agency reviewed when developing the proposed standard for floodplains.

Impact of Siting Facilities in Floodplains

The potential for contaminant releases from facilities located in flood-prone areas is obvious. The cause and severity of release can range from increased leachate production in inundated landfills to a complete washout of facilities. The destructive forces associated with floods depend on the depth, velocities, flood duration, amount of debris in the flood waters, and speed of onset. These factors limit the time for implementation of emergency measures aimed at protecting the facility or removing wastes to a safe location.

Because flooding is a surface water phenomenon, surface waters are the major recipients of contaminant releases. Once contaminants enter surface waters, transport processes are relatively rapid, so the contaminants migrate rapidly to downstream waterways. The rapid transport processes produce large areal extents of surface water contamination. Transport rates are generally maximum during floods due to the high velocities and the large areas covered by water. In coastal or estuarine areas, tidal effects can disperse contaminants both upstream and downstream of the source. Although mixing and dispersion generally dilute contaminant concentrations away from the source, contaminant adsorption to sediments can produce a long-term problem. Contaminated sediments will be both dispersed over the inundated land surfaces and transported downstream as part of the river sediment load after the flood subsides, resulting in widespread contamination.

Because many contaminants tend to adsorb to sediments (e.g., many organics and heavy metals), contaminated stream sediments will remain long after soluble and suspended contaminants have been swept downstream. Suspended contaminants will tend to settle in slow-moving portions of the river or downstream reservoirs. In coastal areas, they may spread up and down the coast as well as offshore. This can produce a long-term contamination problem that can adversely affect downstream water supplies and aquatic resources many years after the source of contamination has been cleaned up. Contaminants in the sediments will continue to leach back into the surface waters and contaminate downstream surface waters. Contaminants in sediments may destroy benthic organisms or enter the benthic food chain, resulting in toxic effects at higher trophic levels (e.g., important fisheries). Recreational use of the waters may also be impaired.

Contamination of surface waters and sediments due to releases from waste management facilities can destroy aquatic organisms directly through toxic effects, including food web accumulation effects of low-level releases, and indirectly through destruction of habitat. Contaminated sediments may destroy spawning grounds for fish and kill shellfish and other benthic invertebrates which inhabit the sediments. Fisheries may be damaged in turn due to elimination of their benthic food supply or through consumption of contaminated organisms. Destruction of spawning habitat or toxicity to sensitive, early life stages may also limit the reproductive success of fisheries. Other indirect effects include changes in species composition and diversity when sensitive species are eliminated and replaced by less desirable pollution-tolerant species. In severe cases, all organisms in the vicinity of the release may be destroyed.

The release of wastes to surface waters may also result in both acute and chronic human-health effects. The primary route to exposure is through the ingestion of drinking water. However, the ingestion of fish and other aquatic organisms that accumulate chemicals is also of concern because human-health effects may exist at low levels of bioaccumulation relative to those that cause effects in indigenous aquatic organisms. Recreational use of surface water for water-contact activities such as swimming can also result in contaminant exposure. A major concern associated with the contamination of the nation's surface waters and human-health effects is that existing ambient water-quality criteria for human toxic and carcinogenic protection are in many cases below the detection limits in water. Therefore, potentially toxic releases from waste management facilities can go undetected. Additionally, the human-health effects of chronic exposures may not be exhibited for decades.

Surface waters represent an economic asset to regional and local areas. Contaminant releases to surface waters that result in widespread, long-term degradation of water quality can affect agricultural and industrial use (e.g., food processing). Any degradation of water quality will result in a loss to the community.

It is difficult and expensive to design preventive measures that can withstand the forces of a major flood. The two major approaches are: (1) flood protection measures that rely on diversion structures such as levees, dikes, and floodwalls to divert the flood waters away from units and prevent inundation, and (2) floodproofing measures that allow the flood waters to come in contact with units, but that include design features to prevent damage. The latter include designing fencing units to prevent impacts from floating debris; grading landfills and land treatment areas to maximize runoff and minimize erosion; and providing drainage systems to facilitate the collection and removal of run on and runoff [MITRE, 1981].

Emergency responses to contaminant releases caused by flooding are difficult to implement and are generally not very effective. The damage occurs with a washout or major release. The wastes can usually not be recovered. Preventive measures such as moving waste to a safe location or erecting flood protection structures prior to an encroaching flood are also difficult to implement due to the difficult working conditions, and the general disruption of transportation systems (i.e., access roads) and other services which generally occur during floods.

Once contaminants are released into the surface waters, they will be rapidly spread over large areas. This may result in long-term sediment contamination that extends far downstream, as well as soil contamination in downstream land areas that were inundated during the flood. These problems may persist for many years after the facility has been cleaned up. Off-site removal of contaminated sediments is generally not feasible due to their large areal extent.

It is generally impossible to monitor a release during a flood because rapid transport and dilution typically move the peak concentrations of surface water contaminants far downstream before they can be measured. Site access is usually a problem during a flood. Even if the site is accessible, a major sampling effort would be required to characterize the temporal and spatial variations in pollutant concentrations. These variations are very important due to the dynamic nature of the contaminant release and flow conditions. It would be difficult to assemble a prepared sampling team given the short lead time and difficult and hazardous working conditions during floods. Monitoring sediments and surface water concentrations after the flood has subsided is generally the only available option. Monitoring fish-tissue concentrations and biological impacts such as changes in abundance, species composition, and diversity may also be important, but this involves a major long-term effort, particularly because important changes often occur gradually over time.

Case Studies

The following case studies illustrate many of the above problems associated with locating waste management facilities in floodplains. The first three cases are in riverine floodplains, while the fourth case is in a coastal floodplain.

The case studies referenced herein document impacts associated with releases of hazardous substances from waste management facilities. The Agency believes that the practical issues of poor maintenance problems, failures in design and/or operating specifications, environmental impacts, and the siting of waste management units in floodplains are the key points regardless of whether the waste is hazardous or nonhazardous.

Case Study 1

Case Study 1 involves a disposal pit site that occupied approximately 185 acres of land and was bordered on the west by a river and on the north by a bayou. The site was located within a 100-year floodplain, and portions of the site were within the 10-year and 50-year floodplains. The river was subject to tidal influence resulting in water elevation fluctuations. Average water surface elevation was 3 feet mean sea level (MSL). Site elevation ranged from 10 to 20 feet MSL, with the major portion of the site at about 12 feet MSL. Surface water drainage at the site was southwest towards the river. Runoff was ultimately discharged to the river via natural drainages.

From the early 1960s to 1967, wastes from local petrochemical industries were disposed in four unlined sand pits. The primary disposal areas consisted of the main waste pit (3 acres) and overflow area, several small waste pits (0.4 acres total), a drum disposal area, a natural lake and a bordering slough.

Flood waters exceeding 15 feet MSL occurred in 1969, 1973, 1979, and 1983. During these flood events, the waste disposal pits were inundated resulting in surficial transport and deposition of contaminants. The dike surrounding the main waste pit was breached resulting in the spread of a black sludge across the 8-acre overflow area east of the main waste pit. This area contains about 43,000 cubic yards of sludge and about 58,000 cubic yards of contaminated soil.

An immediate removal action was performed in 1983 after preliminary sampling showed high organic contaminant concentrations. Several remedial investigations conducted showed that extensive ground-water, surface water, sediment, and soil contamination exist at the site. After reviewing the recommended alternatives, on-site incineration was selected as the most appropriate and cost effective remedial action. Components of the selected remedial alternative include: 1) flood protection during remedial action; 2) installation of a storm water run-on and run-off collection system; 3) excavation of 150,000 cubic yards of soils and sludges with greater than 10 ppm of volatile organics; 4) on-site incineration of the excavated material; 5) on-site disposal of residue ash; 6) backfilling of pits and excavated areas; 7) collection and treatment, if necessary, of contaminated surface water; 8) natural restoration of the upper aquifer; and 9) post-closure monitoring of the upper and lower aquifers.

Engineering design of the incinerator began in 1987 and is expected to take 18 to 24 months to complete. Remedial construction will begin after completion of the design and is expected to take approximately five years. The estimated cost of the remedial action is $93 million, including annual operation and maintenance costs of $41,000 [Draft Case Study, Tetra Tech Inc., June 1987a].

Case Study 2

Case Study 2 is a former chlor-alkali plant located in a rugged area of the Appalachian mountains in terrain consisting of steep ridges and narrow valleys. The plant was at an elevation of 1702 feet and was bordered on the north by a mountain ridge that rises abruptly to an elevation of 2836 feet and on the south by a river with an average elevation of 1682 feet.

A mountain stream, characterized by a coarse rocky substrate with extensive pool and riffle areas, was adversely affected by releases from the site. Near the site, the average river flow rate is 300 cfs. The river continues an additional 80 miles past the site, passing through rural landscape before its confluence with another river branch. The main river flows another 30 miles below the confluence before entering a 30,000-acre reservoir used for drinking water and recreation.

Mercury contaminated wastewaters were either directly released to the river or allowed to settle in two ponds along the riverbank. Even though the facility was closed in 1972, mercury releases to the river have continued because high levels of mercury are leached by runoff that flows through the contaminated sludge of a drained waste pond.

Significant contamination occurred in 1977 when flood waters undercut part of the river bank and accelerated erosion of contaminated soils. High flow rates in the river during most of the 1970s carried mercury and contaminated sediments far downstream.

Mercury contamination extends at least 80 miles downstream of the site. Water, sediments, and fish are all contaminated. In 1973, mercury concentrations in river water exceeded the Federal water quality criteria (acute, 1 hour, criterion of 2.4 μg/l and chronic, 4 day, criterion of 0.12 μg/l). Mercury levels in river water sampled between 1978 and 1981 fluctuated from 0.024 to 0.64 μg/l. In 1970, the State banned fishing in the 80 miles of river downstream of the site because levels in fish exceeded the FDA standard for consumption (0.5 ppm). In 1973, 85 percent of the fish below the site had mercury concentrations greater than 1 ppm. In 1974, three species of fish had average mercury concentration of 2.8 ppm.

Closure and demolition of the chemical production facility in 1972 did not halt mercury releases to the nearby river. In 1983, the State ordered the chemical company to take remedial measures to prevent mercury releases to the environment. These measures consisted of: installing rip-rap material along the river bank in order to prevent further erosion; installing a dike; constructing a diversion ditch to lessen runoff of surface water into one of the ponds; diverting the river from its bed for 1300 feet near the site, followed by dredged removal of contaminated sediments; and permanently disposing of dredged sediments by spreading, encapsulating, and capping them on site.

Continued monitoring of the river indicated that these attempted remedial measures were not completely successful and significant contamination was still occurring. [Draft Case Study, Tetra Tech Inc., June 1987a].

Case Study 3

Case Study 3 is a former oil sludge disposal facility. The sludge was generated by an oil recycling plant located approximately ten miles away. The site was located in a rural area of northeast Florida, adjacent to a stream in some areas and to wetlands within the floodplain of the stream in other areas. The site originally consisted of seven open, unlined, diked pits that operated from 1958 to 1968. Analysis of the waste material indicated the presence of PCBs, phenol, pesticides, acids (less than pH 2), and heavy metals (copper, lead, zinc, cadmium, and chromium).

Both sudden and long-term contaminant releases have occurred at the site. The contaminated wetlands and leachate seeps from the pits have produced a long-term contamination problem. Shock loading of the stream occurs during storms from the heavily contaminated soils in the wetlands north of the pits. After periods of flooding, pools of oil are exposed at the land surface and portions of this oil are washed by overland flow into the adjacent stream. Even short-term rainfall events produce releases. The contamination has entered the wetlands and stream causing fish kills and reducing the aquatic wildlife within the stream to a few tolerant species.

Remedial measures have been implemented by local, State, and Federal agencies since 1968. In 1968, the dike surrounding Pit No. 7 ruptured, spilling the pit contents into the stream and the adjacent wetlands. Little information is available on the nature of the cleanup, but the pit was filled and a two-cell oil and water separator and limestone filter were partially constructed by the local government. Funding problems prevented completion of the construction.

In 1976, a second spill occurred when the dike surrounding Pit No. 6 failed. The spilled oil was removed from the stream and taken to a disposal site twenty-five miles away. The oil and water separator was completed and the discharge water was treated using a carbon adsorption treatment system. The pits were stabilized using clean trash, auto shredder waste, Fullers earth/oil mixture, and clean fill.

In 1981, the pits were capped with clay. The cap was planted with grass and the drainage ditches were modified to their current configuration. This involved adding control structures and filling a ditch that formerly ran along the northern boundary of the site.

Further remedial actions including placement of a slurry wall to isolate the source of leachate are currently being designed. The remedial actions performed to date have resulted in improved surface water quality from runoff, although the quality of water in the stream is still being affected by contaminated leachate entering the stream in the vicinity of the site [Draft Case Study, Tetra Tech Inc., June 1987a].

Case Study 4

Case Study 4 involves a waste recycling facility and storage area. The facility began operation in 1959 to reclaim styrene tars generated by the petrochemical industries. A hurricane destroyed the reclamation equipment in 1961 and the site was used only for waste storage from 1961 to 1968. A variety of petrochemical wastes including tars, styrene, polyetheylene, waste oil, heavy metal salts and sludges, and vinyl chloride were stored on the site in seven unlined pits and nine aboveground storage tanks.

Contaminant releases from the pits have occurred due to overtopping of the dike caused by accumulated rainfall or flooding at the site. The average site elevation is about +5 feet mean sea level. Portions of the site within the pit dike are well below sea level. The local municipality's Flood Insurance Study reported storm surge elevations of 5.6, 10.4, and 12.0 feet for flood frequencies of 10, 50, and 100 years, respectively. Flood frequency data indicates that the site areas outside the dikes will flood once in eight years and that the site will be completely inundated by a 20-year flood having storm surges of 7.8 feet [Draft Case Study, Tetra Tech, Inc., June 1987a].

Surface water leaving the site travels to a drainage ditch which empties into a bayou and eventually into a sub-bay of the Gulf of Mexico. Crab and fish kills have been reported in the bayou following releases of pit water. Complaints of odors and contaminant releases from the site led to the cancellation of the site operating permit in March 1968.

Remedial actions at the site focused on securing the site, and repairing and maintaining the pits and dike. Remedial measures included the removal of drums stored at the site, extending and upgrading the dike surrounding the pits, and securing the area with a 6-foot chain-link fence. Remedial actions were conducted to treat and discharge surface water accumulated within the dikes.

An Initial Remedial Measure (IRM) was conducted for the removal and off-site disposal of wastes stored in the nine aboveground tanks. The tanks were demolished and removed from the site. Off-site investigations were also initiated to collect additional data and information regarding the extent and degree of contaminant migration [Draft Case Study, Tetra Tech Inc., June 1987a].

Case Study Summary

The cited case studies illustrate: (1) the potential for waste releases in floodplains, (2) the common release pathways, and (3) the potential impacts associated with these releases. The observed waste releases were caused by either flooding of waste sites, dike failures, streambank erosion, contaminated runoff, or shallow ground-water contamination that recharges a nearby stream. In all of the cases, continuous or frequent release to nearby surface waters occurred due to failures in design and operating specifications. Flooding, however, had been responsible for rapid dispersion of a large quantity of contaminants. The environmental impacts observed included surface water contamination, fish and aquatic organism kills, and long-term sediment contamination.

Standard

EPA's requirement states that a MSWLF unit located in the 100-year floodplain shall not restrict the flow of the one-hundred (100) year flood, reduce the temporary water storage capacity of the floodplain, or result in washout of solid waste, so as to pose a hazard to human health or the environment. MSWLFs can employ a variety of flood controls to meet this requirement, several of which are outlined below [MITRE Corp., 1980]:

- **Slope** - Location of MSWLFs below grade causes ponding, that can carry wastes out of the MSWLF in solution or suspension, and increase leachate production. A unit slope greater than 2 percent but less than 5 percent will inhibit the ponding effect, but not lead to increased erosion [MITRE Corp., 1980].

- Drainage Capacity - A leachate collection system can be used during emergencies to increase the drainage capacity of a landfill. Permanent drainage channels or ditches should be constructed on the uphill side of the MSWLF to divert water around the site. Portable drainage structures can be used during flooding, however, the speed of onset of the flood must be considered in choosing portable drainage structures for flood protection [MITRE Corp., 1980].

- Fencing - Any fencing used around a MSWLF should be permeable. Permeable fences will allow water to pass through, making them less likely to be carried away by the floodwaters, and reducing the potential impact damage caused by the debris content of the floodwaters.

- Diversion Structures - Levees are the most commonly used diversion structure, however, floodwalls and ditches can also be used. Levees are generally constructed of earthen materials and are designed to provide flood protection from seasonal high water. As mentioned earlier, levees are subject to failure from underseepage as a result of flood inundation [MITRE Corp., 1980]. Flood walls are constructed of permanent construction materials such as concrete or steel sheet piping, and are designed to prevent inundation of adjacent land [MITRE, Corp., 1980].

The Guidance Manual for Classifying Solid Waste Disposal Facilities [EPA, SW-828, 1980] provides guidance for determining if a facility complies with 40 CFR 257.3-1. Because EPA's rule for MSWLFs is almost identical to 40 CFR 257.3-1, this guidance manual may be used to determine compliance with the new criteria. The first step in the determination of compliance is to determine if the MSWLF is located in the 100-year floodplain. This information can be obtained from existing permits and operation applications, or from 100-year floodplain maps. One hundred-year floodplain maps are generally available from the following sources [EPA, SW-828, 1980]:

- State Flood Control Agencies or other departments,
- Federal Emergency Management Agency (FEMA), Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map (FHBM),
- Local and Regional Planning and Zoning Agencies,
- Soil Conservation Service - U.S. Department of Agriculture,
- U.S. Army Corps of Engineers,
- National Oceanic and Atmospheric Administration,
- Federal Housing Administration (HUD),
- U.S. Geological Survey,
- Bureau of Land Management - Department of the Interior,
- Bureau of Reclamation - Department of the Interior,
- Tennessee Valley Authority,
- River Basin Commissions and Special Flood Control Districts, and
- Local and State agencies involved with public works construction, (i.e., bridges, culverts, highways, channel improvements and urbanization studies).

Additional assistance can be obtained from:

- The State agency charged with flood protection or floodplain management,

- Any of the map source agencies previously listed with the necessary expertise, or

- A qualified professional firm.

Attachment 15 (Appendix A) lists other sources of floodplain information. Water Resources Council Bulletin Number 17A [1977] provides guidance for determining flood flow frequency.

Once the location of a MSWLF relative to the 100-year floodplain has been determined, those facilities located in the 100-year floodplain should be prioritized according to the relative risk posed to human health and the environment. The factors influencing the flood hazard potential posed by a MSWLF are illustrated in Attachment 16 (Appendix A).

Once priority has been determined, a facility should be assessed to determine if it is protected from washout by the 100-year flood. Consideration should be given to the following factors [EPA,SW-828, 1980]:

(1) Types and effectiveness of washout protection used in each area of the facility below the 100-year flood level including:

    - dikes,
    - levees,
    - berms,
    - flexible linings,
    - vegetative cover,
    - riprap,
    - diversion of high velocity flows around the facility, and
    - change in soil matrix by chemical alteration.

(2) Flood flow velocity; using a flood flow velocity of at least 2.5 times the average velocity over the entire floodplain cross-section for those portions of the facility in the floodway and a minimum value of 1.0 times the average

velocity over the entire floodplain cross-section for those portions of the facility in the floodway fringe.

That is: $\bar{v} = Q/A$

where

$\bar{v}$ = average velocity

Q = 100-year flood flow (cfs)

A = cross-sectional area of floodplain

Matrices comparing the types of washout protection with different flood flow velocities by showing the efficiencies of each type at different velocities are available in DOT's Hydraulic Engineering Circular No. 15 and the Corps of Engineer's Shore Protection Manual [EPA, SW-828, 1980]. These matrices can be used to help evaluate the adequacy of protection for each facility.

C. WETLANDS

The wetlands of the United States, comprised in part of inland and coastal swamps, bogs, marshes, sloughs, mudflats, wet meadows, natural ponds and river overflows, serve as important natural hydrologic, ecologic, social and economic resources. Scientific studies have come to recognize wetland habitats as essential breeding, rearing and feeding grounds for numerous species of fish and wildlife, including many endangered species. These ecologically sensitive habitats have been linked to playing an important role in both flood protection and pollution control. General public, governmental and commercial opinions, however, have had little concern for wetlands protection, thus these areas were inconsistently regulated by either Federal, State or local governments. The adverse consequences of such policies resulted in the direct destruction of an estimated 48 million acres of wetlands through draining, dredging, and landfilling of wetlands for agricultural residential and commercial development. [43 FR 4942, February 6, 1978]. A recent study conducted by the Office of Technology Assessment (OTA) has estimated that based on current policies and trends that an estimated 300,000 acres of wetland resources will be lost per year. Increasing scientific understanding of the functions and values of wetlands indicates that this conversion causes serious economic costs throughout the country [Baldwin, 1985].

The valuable functions of wetlands and aquatic ecosystems have come to be recognized by the public and State and Federal regulating authorities. Despite these concerns, wetland protection programs are neither comprehensive nor consistent (see OTA Report p 3-13). The Clean Water Act (CWA) Pub. L. 92-500 as amended by Pub. L. 95-217 and Pub. L. 95-576; 33 U.S.C. 1251 et seq., stands alone in addressing adverse effects to wetlands by regulating impacts to "waters of the Unites States." An expansive definition of the latter has been viewed to indirectly encompass wetlands. This view has not been without controversy. The ambiguousness of the statuatory language has lead to the dispute over varying legal interpretations as to what Federal agency or agencies have primary authority for implementation of a Federal regulatory program to protect wetlands from solid waste disposal. The result has been an inconsistent and often incomprehensive wetland protection system, ultimately mandating a reevaluation of present policy and issuance of a natural wetlands protection standard administered soley through and by the EPA.

The proposed Subtitle D standards of the Resource Conservation and Recovery Act (RCRA) discussed herein, concentrate on the disposal of municipal solid wastes in wetlands and those measures required by the Federal government (EPA), to assure nondegradation of sensitive wetland ecosystems. The definition of wetlands proposed is in accordance with CWA Section 404(b)(1) and implementing regulations of 40 CFR 230.4(t). The term "wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include, but are not limited to, swamps, marshes, bogs, and similar areas.

The justification for protecting wetlands focuses on the importance of the ecological services on resource values that wetlands provide including the following ecological benefits [Office of Technology Assessment, 1984]:

- Wetlands store runoff and slow the downstream flow of water, thus reducing floodpeaks and frequency of flooding in downstream areas;

- Temporarily or permanently retaining pollutants, wetlands can improve, to varying degrees, the quality of the water that flows over and through them;

- Wetlands provide food and habitat for many game and non-game animals. Approximately 20 percent of all plant and animal species listed by the Federal government as threatened or endangered depend heavily on wetlands;

- Wetlands may significantly reduce shoreline erosion caused by large waves and major coastal and riverine flooding;

- Some wetlands are recharge areas to ground-water systems supplementing local or regional ground-water supplies through infiltration/percolation of surface water.

Wetland environments may be adversely impacted in several ways from the location of solid waste land disposal facilities in these sensitive areas. The primary concerns of depositing wastes into wetlands are the physical disturbance and potential impacts of accidental discharges of wastes into wetland ecosystems [GCA, 1986b]. These physical and/or accidental impacts can have a direct effect on the chemical, biological, and human use characteristics of aquatic ecosystems. 40 CFR 230.42(a)(3)(b) states:

> The loss of wetlands.... is likely to damage or destroy habitat and adversely affect the biological productivity of wetland ecosystems by smothering, by dewatering, by permanently flooding, or by altering substrate elevation or periodicity of water movement. The addition of materials may destroy wetland vegetation or result in advancement of succession to dry land species. It may reduce or eliminate nutrient exchange by a reduction of the systems productivity, or by altering current patterns and velocities. Disruption or elimination of the wetlands system can degrade quality by obstructing circulation patterns that flush large expanses of wetland systems, by interfering with the filtration function of wetlands, or by changing the aquifer recharge capability of a wetland. Accidental discharges can change the wetland habitat value for fish and wildlife. When disruptions in flow and circulation patterns occur, apparently minor loss of wetland acreage may result in major losses through secondary impacts.

Further impacts resulting from the degradation of wetlands by foreign substance intrusion cause the destruction of recreational and commercial fisheries. The effect of materials being placed in wetlands can affect the suitability of recreational and commercial fishing grounds as habitat for populations of consumerable aquatic and terrestrial organisms through the destruction of migration and spawning areas and reproducing organisms, that they may be dependent on as food sources (40 CFR Part 230.51(b)). Other economic/social concerns include aesthetic, recreational, scientific, and educational values that these natural aquatic areas provide to the public.

Existing Programs

A review of Federal and State policies for the protection of wetland resources have identified gaps in the wetlands protection regulatory scheme that do not provide adequate protection from waste disposal. This fact and the recent revitalization of the Federal solid waste management program resulting from the Hazardous and Solid Waste Amendments of 1984, have renewed interest in using RCPA to provide wetlands protection from solid waste disposal that would solely be implemented through and by the Agency. The need for this approach can be best exemplified through an overview of the present Federal statutes, regulations and executive orders that are responsible for the protection of the nations wetlands [GCA, 1986b].

The CWA is currently the primary Federal statute providing protection to the nations wetlands. Although not a Federal wetlands protection statute as such, the CWA provisions ensuring protection of the "waters of the U.S." have been expansively interpreted by the courts and are applicable to almost all wetlands resources (See 392 F. Supp 685 (D.C.D.C. 1975)). Regulatory programs established under §§404 and 402 of the CWA extend regulatory control over discharges including discharges of solid waste into wetland areas. Statutory exemptions contained in §404(f) and longstanding jurisdictional disputes, however, limit the CWA's ability to regulate the disposal of solid wastes in wetlands [GCA, 1986b].

Pursuant to §404 of the CWA, the Corps of Engineers controls, through the issuance of permits for specified sites, activities that result in the "discharge of dredged or fill material" into waters of the U.S., including wetlands. The Corps has promulgated regulations, contained at 33 CFR Parts 320, 323, and 325, prescribing policies and procedures for implementing the §404 program. The issuance of permits is carried out in accordance with guidelines developed by EPA and the Corps jointly under §404(b)(1) of the CWA. These guidelines, contained in 40 CFR Part 230, provide criteria by which the Corps evaluates the environmental effects of a proposed discharge of dredged or fill material on a particular site. They prohibit discharges if there is a practicable alternative with less adverse impact on the aquatic environment. EPA participates in the permit process pursuant to regulations promulgated at 40 CFR Part 231, and under the authority of §404(c) of the CWA, may restrict or prohibit the specification of any site by the Corps where it would result in unacceptable adverse impacts on fish, wildlife, water supplies, or recreation [EPA, 1986b].

As implemented by the Corps, the §404 program has not controlled the disposal of solid or hazardous waste in wetlands. As defined in Corps regulations at 33 CFR 323.2(k), "fill material" does not include waste discharged for the primary purpose of disposal:

> (k) The term "fill material" means any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of any waterbody. The term does not include any pollutant discharged into the water primarily to dispose of waste, as that activity is regulated under Section 402 of the Clean Water Act.

The Corps, therefore, has not required a permit under its §404 authority for the disposal of solid waste material in wetland areas, maintaining that waste disposal is the discharge of pollutants more properly regulated under §402 of the CWA [GCA, 1986b].

Pursuant to §402 of the CWA, EPA controls, through the issuance of permits, the discharge of pollutants from point sources into waters of the U.S., including wetlands. EPA has promulgated regulations, contained at 40 CFR Parts 122-125, for the establishment and implementation of the §402 National Pollutant Discharge Elimination System (NPDES) program. Pursuant to these regulations, EPA or States with authorized programs issue permits to all point source discharges into waters of the U.S. These permits incorporate technology-based effluent limitations developed by EPA for classes of point sources [GCA, 1986b].

The §402 NPDES program has not controlled the disposal of solid waste in wetlands because EPA has maintained that such waste is within the definition of "fill material;" therefore, such waste disposal in a wetland is a discharge of fill material that requires a permit under §404. EPA promulgated a definition of "fill material" to this effect in the consolidated permit regulations for the NPDES program at 40 CFR §122.3:

> Fill material (404) means any "pollutant" which replaces portions of the "waters of the United States" with dry land or which changes the bottom elevation of a water body for any purpose. [emphasis added]

Furthermore, EPA has argued that §402 of the CWA does not authorize site evaluation in the permitting process as §404 does, and as a result, limits the §402 permit to controlling point source effluents and not protecting wetlands resources. EPA, therefore, has not required permits under its §402 authority for the disposal of solid or hazardous waste material in wetland areas [GCA, 1986b].

Recognizing the serious gap between the EPA and Corps definitions of "fill material," EPA developed an interim strategy to control unregulated discharges into wetlands. Articulated in the preamble to the §404(b)(1) guidelines, the strategy called for the use of EPA's §309 enforcement authority to constrain or condition unpermitted waste disposal until resolution of the definitional conflict and permit issuance by the appropriate program could ensue. Without resolving which was the appropriate program, EPA and the Corps agreed to retain any permit applications received in order to avoid unnecessary confusion in the administrative process [GCA, 1986b].

The impasse between EPA and the Corps over CWA jurisdiction with respect to waste disposal did not escape the attention of environmental groups, who brought suit to force resolution of the issue. (See, N.W.F. v. Marsa (D.C.D.C. 1983). As part of the settlement of this suit, EPA and the Corps consented to enter into an agreement to resolve the longstanding dispute. The resulting Memorandum of Agreement (Attachment 17, Appendix A), represents an interim arrangement between EPA and the Corps for controlling solid waste disposal in waters of the U.S. The intent of the agreement is to ensure effective enforcement by EPA under §309 of the CWA to control existing or ongoing unpermitted discharges of solid waste into wetlands. For proposed discharges, it also established criteria for determining whether §402 or §404 permit requirements apply. In accordance with these criteria, certain homogeneous wastes are to be regulated under §402 and certain heterogeneous wastes are to be regulated under §404. This is an interim arrangement, however, and both EPA and the Corps agree that in the long term, expanded RCRA control over solid waste may provide the solution to protecting wetlands from the unregulated disposal of waste material [GCA, 1986b].

Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. §401 et seq.), often used concurrently with §404 of the CWA, requires permits for structures of work in or affecting navigable waters of the U.S. This includes any dredging or disposal of dredged material, excavation, filling, or other modification of a navigable waterway of the U.S. Although not specifically designed to protect wetlands, §10 has been used to provide protection to wetlands in some circumstances. The Corps, which also administers the §10 permit program, has promulgated permitting policies and procedures in regulations contained in 33 CFR Parts 320, 322, 325. These regulations do not address disposal of waste, other than disposal of dredged material, and offer only limited protection to wetlands with respect to disposal of solid waste [GCA, 1986b].

The Coastal Zone Management Act of 1972 (16 U.S.C. §1451 et seq.) addresses the protection and use of the land and water resources of the Nation's coastal zone, including coastal wetlands. The Act declares that it is national policy to protect the natural resources, including wetlands, floodplains, estuaries, and fish and wildlife and their habitat, within the coastal zone. This policy is achieved through State coastal zone management planning, with technical and financial assistance provided by the Federal government. Regulations implementing this program have been promulgated by the Department of Commerce at 15 CFR Part 923. According to these regulations, State management plans should address control of water pollution affecting resources in the coastal zone. To the extent that they do, they may provide State control over solid waste disposal in coastal wetland resources [GCA, 1986b].

The Fish and Wildlife Coordination Act (16 U.S.C. §661 et seq.) requires consideration of wildlife conservation values by the Corps and other Federal agencies in Federally-sponsored and Federally-permitted water resource development projects. The Act also authorizes the Fish and Wildlife Service and the

National Marine Fisheries Service to review such projects to ensure the protection of fish and wildlife resources. Although this requirement includes the review of §404 projects affecting wetland resources, actual participation in the§404 permit decision-making process has been the subject of interagency dispute [51 FR 8871, March 14, 1986].

In theory, the Act's provisions authorize protection of wetland fish and wildlife resources through §404 permit decisions with respect to waste disposal. In practice, however, these provisions provide little control over wetland resource damage caused by waste disposal as long as the §404 program fails to require permits for the disposal of waste in wetlands [GCA, 1986b].

More narrowly defined than the Fish and Wildlife Coordination Act, the Endangered Species Act of 1973 (16 U.S.C. §1531 et seq.) restricts Federal activities that may jeopardize the continued existence of threatened or endangered species or may destroy or adversely modify their critical habitat. The Department of the Interior and the Department of Commerce have jointly promulgated regulations, contained at 50 CFR Part 424, implementing the provisions of the Act. Although not expressly written as a wetland protection statute, the Act's provisions control Federally- sponsored activities, including where solid waste disposal may adversely affect the critical habitat of a threatened or endangered species. Because the number of endangered species and critical habitats is relatively limited, however, the wetlands protection provided by the Act is extremely limited and does not provide an overall approach to protecting wetlands from nonregulated solid waste disposal [GCA, 1986b].

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. §4321 et seq.) requires thorough consideration of environmental impacts before "major Federal actions" or Federally-permitted activities "significantly affecting the quality of the human environment" may be undertaken. The environmental impact statement required by the Act for a Federal project is the decision-making tool that ensures that the environmental effects of the project are identified and understood and that practicable alternatives are considered. Wetland impacts are considered among the concerns raised in a thorough environmental impact statement [GCA, 1986b].

The availability of the Act to control disposal of solid waste in wetlands, however, is questionable. Because the Act's requirements apply only to major Federal actions significantly affecting the environment, it is unlikely that much solid waste disposal in wetlands falls within the scope of these provisions. Even in cases where the Act does apply, it does not necessarily prohibit or constrain Federal actions; it merely requires full consideration of impacts and alternatives. This does not represent the comprehensive control needed to protect wetlands from waste disposal activities [GCA, 1986b].

The Food Security Act of 1985 (Public Law 99-198, §1222) includes important measures to discourage conversion of wetlands to agricultural lands. Specifically, if a farmer converts wetlands, he or she will become ineligible for any type of price support, farm storage facility loan, crop insurance, disaster payment, loans under the Consolidated Farm and Rural Development Act, and payments under Sections 4 or 5 of the Commodity Credit Corporation Charter Act. The Food Security Act contributes to reducing wetland conversions to agriculture, but does not directly pertain to waste disposal in wetlands [GCA, 1986b]

President Carter advanced Federal protection of wetlands in 1977 by signing Executive Orders 11990 for protection of wetlands and 11988 for floodplain management. These Federal directives prescribe measures to be taken by Federal agencies to avoid adverse impacts on wetland and floodplain resources [GCA, 1986b].

Executive Order 11990 (Attachment 18, Appendix A) articulates a strong Federal policy favoring the protection of wetlands. It directs Federal agencies, in carrying out their responsibilities, to take action to minimize the destruction or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. It also requires Federal agencies to avoid undertaking or providing assistance for new construction, including draining, dredging, and filling activities, in wetland areas unless there is no practicable alternative and only if measures are taken to minimize the harm to wetlands. The Executive Order remains in effect today, and, to the extent that Federal agencies are complying with its terms, it has a potentially significant effect on Federal activities with respect to wetlands [GCA, 1986b].

In principal, at least, Executive Order 11990 appears to control Federal activities involving waste disposal in wetlands. In practice, however, Federal directives like this is largely self-enforced by Federal agencies themselves, so it is difficult to measure the extent to which Federal waste disposal in wetlands has actually been affected. Beyond this issue, of course, is the larger question of private, non-Federal waste disposal activities in wetlands, activities that the Executive Order does not apply [GCA, 1986b].

In an effort to fill in the gaps left by Federal government policy, individual States have promulgated a variety of statutes and regulations for the protection of wetland areas from waste disposal. The amendments to the CWA established a system whereby the State could assume a significant role in the dredge and fill program. The objective was to return responsibility for certain decisions affecting land use to the States and to limit duplication of effort. The State programs are essentially a mirror of the Federal program, complying with the §404 guidelines. EPA's role is as an overseer through approving State programs and monitoring decisions made under them [EPA, C-6, 1979].

The States, however, have not acted in a consistent fashion. Individual States have enacted a variety of statutes and regulations, some of which regulate waste disposal directly, while others do go only by implication. There are also a large number of States with legal authorities that do not mention either "waste disposal" or "wetlands", but where language is written broadly enough to address the problem [GCA, 1986b]. Those States that have assumed the lead in wetlands protection policies often differ vastly in their criteria for ranking, classifying and/or evaluating wetlands. Similarly, States do not uniformly assess wetland aesthetic and economic resource values or differentiate between new and existing waste facilities.

The absence of a Federal program specifically dedicated to overall wetlands protection coupled with the lack of adequate criteria under present RCRA Subtitle D standards and the apparent jurisdictional and interpretative disputes associated with key sections of the CWA have resulted in the burden of wetlands protection from waste disposal being left to the individual. Thus the regulatory programs that currently exist lack consistency nationwide and the degree of control exercised appears to be entirely dependent on the motivation of individual States.

The ineffectiveness of the present Federal system can be reiterated through the review of EPA's use of its veto authority under §404(c). Although the Corps releases about 11,000 permit requests each year, permit denials are estimated to be less than 3 percent, with only a few §404(c) veto actions being taken by EPA. Only about a dozen permit controversies with the Corps have been evaluated by regional offices for resolution to the Washington Headquarters under §404(q) procedures. The rare use of §404(c) reflects the unusual role created for EPA by Congress as an overseer of another agency's regulatory program [Baldwin, 1985]. A rough estimate of current national wetlands loss exemplifies the present problems of the Federal systems implementation. There are approximately 99.0 million acres of wetlands in the 48 contiguous States that make up 5 percent of the total area [EPA, 1987]. Of the 99.0 million acres, between 300,000 and 500,000 acres of wetland resources are adversely impacted annually. Studies indicate that 50,000 acres of this loss is estimated to be permitted under §404. An unknown amount of loss occurs through discharges that could come under §404 jurisdiction but that are currently unregulated or illegal. This factor is probably at least equal to the amount of permitted loss [EPA, 1986b]. EPA believes that these unnecessary losses can be prevented through a comprehensive and consolidated Federal system, one that does not depend on the interactions of different Agencies that have different Federal (EPA) administrative and substantive duties, but a policy that would be based on the development of a national criteria and standards as its ultimate goal. The RCRA amendments present an opportune time for EPA to implement wetlands protection through establishing facility location criteria under these proposed Subtitle D documents.

Impacts of Siting in Wetlands

The Agency's justification for the proposed changes in the RCRA Subtitle D regulations are predicated on the analysis of the environmental impacts concurrent with siting MSWLFs in wetlands. The Agency examined various case studies of existing units located in wetlands that illustrate the types of environmental problems that have occurred and that may be mitigated through the implementation of the revised Criteria.

The case studies reviewed document the specific types of impacts connected with the location of waste management operations in or adjacent to wetlands. Each case study exemplified the high potential for contaminant releases due to the close proximity of surface waters, the potential for flooding, the shallow water table conditions and adverse affects of accidental spills and releases (e.g., leachate seeps, surface impoundment overflows, and dike failures).

Wetlands are commonly adjacent to or contain surface waters and by definition have saturated soils and a shallow water table. Therefore the release often affects surface waters and ground waters in addition to the wetlands. Surface water transport results in extensive surface water and sediment contamination. The difficulties in performing corrective actions due to the widespread contamination, and the extensive wetland disruption that would be involved in sediment removal, are key depictions of the several case studies examined.

It should be noted that the documented case studies referenced herein deal with the release of hazardous substances into wetland environments. The Agency believes that regardless of the types of contaminants released, hazardous or nonhazardous, the fundamental issues associated with these case studies highlight the breakdown of the containment units that provide safe and adequate protection to the environment from uncontrolled releases of constituents. The following case studies illustrate many of the problems associated with locating waste management units in wetlands.

Case Study 1 - Tinicum Marsh

Tinicum Marsh is a 1200-acre National Wildlife Refuge in Pennsylvania. It is the largest freshwater tidal marsh in the State and attracts over 37,000 recreational users annually. This study involved two landfills located in the freshwater tidal marsh. One of the two landfills extended below the local water table. Major leachate flows were observed flowing into nearby creeks, streams and the marsh. Field investigation studies identified the migration of contaminants from the landfills via seeps, surface runoff and ground water discharges. It was also observed that neither of the landfills had liners or leachate collection systems.

Costly remedial measures undertaken to abate the problem proved only partially successful. The landfills were graded and covered to encourage runoff and re-seeded to restrict erosion. However, subsequent studies identified continuous leachate seeps transporting contaminant into the wetlands [Draft Case Studies; NUS Corp., June 1987].

Case Study 2 - Burnt Fly Bog

The Burnt Fly Bog facility was in operation from 1950 to 1969, and was the site of several types of activities including the storage and settling of reprocessed oil and the storage of filter clays from preprocessing oil. Oil used for road resurfacing was stored and settled in four unlined lagoons.

This case study identifies the adverse impacts from siting the four lagoons in a wilderness bog (hardwood swamp forest). The dikes surrounding the lagoons breached releasing contaminants into the wetlands. Though the main facility covered 10 acres, contaminant migration affected 60 acres. The affected bog contributes headwaters to a major river and provides recharge for a localized deep aquifer downgradient of the site. Both are used as sources of drinking water.

A subsequent remedial investigation showed that contaminant releases occurred at the site through a number of pathways including: runoff over contaminated soils and waste piles; leachate from unlined lagoons; overtopping and accidental releases from lagoons, intentional releases; migration from buried sludge piles; and erosion of contaminated soil.

Contaminant clean-up from the wetlands requires sediment removal that would disturb vegetation and further increase erosion and sedimentation. Disturbance of sediments could also mobilize contaminants into the surface waters, that would in turn degrade surface outflows from the western wetlands and escalate the movement of contaminants throughout the entire bog. To prevent these releases sediments were not removed and contaminants in the wetlands were left to naturally degrade and slowly leach away [Draft Case Studies; NUS Corp., June 1987].

Case Study 3 - Sapp Battery Site

The Sapp Battery site is a former lead recycling facility that processed used automobile batteries from 1970 to 1979. The facility was located in a rural cypress swamp area in northern Florida to the north of Steele City Bay. At its peak operation it was processing 50,000 batteries a week. Battery acid was originally dumped outside the plant and allowed to run into the swamp.

During site investigation, it was discovered that releases had occurred in all media: soils, surface waters, sediments, ground water and air. High levels of contamination were measured in surface water and sediments near the site. Fish habitat had been destroyed and fish were eliminated altogether in areas with the highest contaminant concentrations. Downstream, fish and macroinvertebrates showed a gradient pattern of reduced species richness, diversity, and numbers of individuals. Cypress trees in the area as well as downstream of the site were destroyed by contamination.

Remedial measures implemented were ineffective in reducing the contamination. After closure, emergency remedial actions were performed that included: neutralizing the acid holding pond with hydrated lime; disking the surface soils with hydrated lime; constructing trenches to intercept the runoff between the facility and the adjacent swamp and between the swamp and the culvert to Steele City Bay, and backfilling them with hydrated lime; and extending and reinforcing the existing berms.

However, the pH of the water bodies returned to their previous low levels within one month, requiring further remedial measures that included: draining the acid holding pond and excavating contaminated soil and bottom sludge and removing it off site; backfilling the holding pond and excavated area with clean soil and installing a temporary clay cap and PVC liner; treating the acid holding pond liquid with lime, sodium sulfide, and polymer; installing a rip-rap filter drain where drainage from the liner flows into the west swamp; extending and reinforcing existing berms to further reduce drainage into Steele City Bay; installing a weir between the west and east swamp to collect lead-contaminated sediment; excavating and removing a large amount of battery casing debris and contaminated soil off site; and installing a fence with warning signs around the highly contaminated area.

Subsequent sampling indicated that contamination still occurs at the site, although some samples indicated a general trend of reduced pollutant concentrations with time. Further remedial actions are currently under investigation [Draft Case Study, NUS Corp., June 1987].

Case Study 4 - Re-Solve Site

This waste chemical reclamation facility (6 acres) located in a rural section of southwestern Massachusetts is sited adjacent to wetlands to the north and east. Sludge from a distillation unit was disposed of in four unlined lagoons located in the northern portion of the facility near the wetlands. All four on-site residue lagoons drain directly to the wetlands area. In addition, the wetlands receive runoff from a large oil-spreading area south of the lagoons. The wetlands are largely ponded water 1 to 2 feet deep. The wetlands water serves as headwater for a tributary that flows directly to an adjacent river within 500 feet of the site. This tributary is typically the most contaminated surface water near the site because it receives flow from both the wetlands and contaminated ground water passing through the facility.

The area of off-site contamination is extensive. The wetlands north of the site are contaminated with PCBs to a depth of 1.5 feet. The sediments in the tributary draining the wetlands are contaminated with PCBs to a depth of 1 foot as far as 300 feet downstream of the wetlands outlet. Some PCBs are found redeposited in the sediments of the pond 0.5 mile downstream.

Surface waters contaminated with volatile organics, were found as far away as the downstream pond (0.5 mile). Analyses of fish from the river and pond showed PCB concentrations exceeding the FDA limit for human consumption.

In 1981, the site owners surrendered their operating license and removed drums and debris from the site and demolished buildings. The entire area with the exception of the foundations and concrete loading pads was covered with sand. The contents of the lagoons in the north portion of the site remained intact and were not removed. Remedial action included excavation of the contaminated lagoons and site soils from on-site areas. The plan also called for capping the remaining contamination on site, providing a final cover, providing drainage, and seeding the area. During excavation, extensive off-site soil contamination was discovered, particularly in the wetlands that had served as the receptor of drainage from the lagoon area.

Alternative remedial measures for the contaminated wetlands currently under consideration include excavation of wetland areas and the adjacent tributary, construction of in-place silt barriers, and capping the area with non-eroding material. Some of these measures could result in destruction of the affected wetland areas [Draft Case Study, NUS Corp., June 1987].

Summary of Case Studies

The sites depicted in the case studies were uncontrolled and were not operated under current RCRA design and operating regulations for Subtitle C or D facilities. It is the belief of the Agency, however, that current design and operating requirements, along with the demonstration requirements, could have prevented such releases or prevented the facilities from siting in such environments. Thus the need for extensive and costly corrective action measures could have been mitigated.

Standard

The Subtitle D criteria discussed herein includes provisions that impose a ban with a variance on locating MSWLFs in wetlands. EPA believes this action is necessary because these facilities cause irreparable harm to these sensitive ecosystems. This approach is consistent with Agency policy for the protection of the Nation's wetland resources. This policy has been articulated over the years in various Agency directives on wetlands, beginning with the policy statement issued by the first EPA Administrator in 1973. It also is embodied in regulatory form in the Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR Part 230) promulgated under §404(b)(1) of the Clean Water Act. This action also fulfills part of the Agency's commitment under the January 22, 1986, Memorandum of Agreement with the Army Corps of Engineers to address the disposal of solid waste in wetlands under RCRA.

Most recently, the Agency has identified wetlands protection as a top priority, specifying aggressive implementation of the §404 program, increased enforcement against illegal discharges, and other measures as may be necessary. To this end, the Agency considers the wetland requirement an essential measure for protecting wetlands resources.

To be consistent with the Clean Water Act, the revised Criteria adopts the definition of wetlands used in the §404(b)(1) guidelines. These guidelines, first promulgated in 1975 and then amended in 1980, specify the analytical tools to be used in evaluating and testing the impact of dredged or fill material discharges on waters of the United States, including wetlands. Fundamental to the guidelines is the precept that discharges into aquatic ecosystems should not be allowed unless it can be demonstrated that such discharges will not have an unacceptable effect. In particular, the guidelines identify filling operations in wetlands as among the most severe environmental impacts covered. For this reason, the guidelines are directly relevant to solid waste disposal activities in wetlands and provide the basis for decision making with respect to such activities.

Under the proposed rule, existing landfills that are located in wetlands and operating in compliance with the CWA provisions are allowed to continue to operate. An estimated 6% of all MSWLFs are in wetlands. EPA recognizes that requiring such facilities to close would not produce significant improvement in the adverse impacts on the ecosystems. Lateral expansions of these facilities are banned, however, unless the owner or operator can meet the waiver requirements specified in the rule. This waiver from the ban is based on a series of demonstrations similar to those listed in §404(b)(1) guidelines. The importance of these demonstrations is discussed below.

The Subtitle D criteria essentially adopts the restrictions on discharge contained in §230.10 of the guidelines and requires them in the form of demonstrations to be made before a facility can be located in wetlands. The provisions place the burden of proof for these demonstrations on the discharger, this is consistent with the guidelines. Failure to make any of the following demonstrations will bar the MSWLF from siting in a proposed wetlands site.

First, the MSWLF owner or operator must consider and evaluate alternative sites to the wetlands and demonstrate that no environmentally acceptable "practicable alternative" is available. The §404(b)(1) guidelines provide guidance on the meaning of the term "practicable alternative." It must be noted that the two presumptions incorporated into this demonstration (i.e., that alternatives that do not involve wetlands are available and that such alternatives have less adverse impact on wetlands) make the alternatives analysis the single hardest demonstration for the MSWLF owner or operator to meet.

Second, the owner or operator must ensure that siting in the wetlands does not violate any provisions of applicable laws. For this purpose, the proposed rule identifies State water quality standards, the CWA §307 standards, species and habitats protected under the Endangered Species Act of 1973, as amended, and marine sanctuaries protected under the Marine Protection, Research, and Sanctuaries Act of 1972. The §404(b)(1) guidelines provide guidance on the violations prohibited by this demonstration.

Third, the MSWLF owner or operator must demonstrate that siting the landfill in wetlands will not result in "significant degradation" of the wetlands. The §404(b)(1) guidelines provide guidance on the full meaning of this term. In brief, effects contributing to significant degradation include: (1) adverse effects on human health or welfare; (2) adverse effects on life stages of aquatic life or other wildlife dependent on the wetlands; (3) adverse effects on ecosystem diversity, productivity, and stability (e.g., a wetlands capacity to assimilate nutrients, purify water, or reduce wave energy); and (4) adverse effects on recreational, aesthetic, and economic values.

Fourth, the MSWLF owner or operator must demonstrate that appropriate and practicable mitigation measures have been taken to minimize potential adverse impacts of the landfill on the wetlands. These may include careful decisions with respect to the nature of the site chosen, the solid waste to be disposed of, any protective technology employed, and attention to plant and animal populations and human use. The §404(b)(1) guidelines identify a number of possible measures.

Finally, the owner or operator must demonstrate that sufficient information is available for making reasonable determinations with respect to these demonstrations, otherwise, the owner or operator cannot make the demonstrations necessary to qualify for the waiver to the ban. This last hurdle places the burden for making the required demonstrations squarely on the MSWLF owner/operator.

EPA recognizes the burden that these requirements place on the MSWLF owner and/or operator who wishes to site a new facility, or expand an existing one, in wetlands. EPA believes, however, that the Nation's wetlands are sensitive ecosystems that merit the protection afforded by these requirements. For this reason, the revised Criteria state that no new MSWLF units shall be located in wetlands without meeting the demonstration discussed above.

These standards are the cornerstone of the development of a centralized, effective and comprehensive program under EPA's legal authority. The Subtitle D program criteria provides EPA with the means and authority to regulate all aspects of waste disposal management, extending to regulation of wetlands protection through these environmental location standards and considerations. The resulting impact of the implementation of the standards will be the promotion of a uniform method for controlling the evaluation, ranking and classification of the importance of wetland resource functions and values. Such a policy will resolve past conflicting guidelines for EPA and States for the protection of wetlands with regards to solid waste disposal.

Successful transformation of this policy into a working program will require utilizing existing State wetland protection experiences. Some States have excelled beyond past Federal wetlands protection policies and have improved their technical, legal and administrative ability to protect wetland resources. The EPA will thus be able to draw upon new scientific and regulatory techniques established by the States establishing an information exchange network. An example of a comprehensive State wetlands protection innovation is the New York State's Freshwater Wetlands Act, that provides protection to wetlands over 12.4 acres. The act requires the State to prepare freshwater wetland maps and to rank these mapped wetlands in classes according to their value. Another example is Wisconsin's Department of Natural Resources Wetland Evaluation Methodology Committee that utilizes evaluations of aesthetics, economic value of a wetland and scarcity, and is developing a computer software program for ensuring maximum ease and practicality of use. Though these are only a few examples of States regulatory programs, the progressive experiences in these and other States can be assessed and applied by EPA for the benefit of wetlands protection [Baldwin, 1985].

Alternatives

The alternative methodologies for wetlands protection from the disposal of solid wastes into these sensitive environments is limited and consists of: the revised standard identified herein; no standard; or a total ban standard. The revised standard and justifications have previously been identified and do not warrant further explanation in this section.

The alternative of the no standard does not constitute any type of wetlands protection thus may lead to the acceleration of the destruction of wetland resources. The social/economic losses of such a policy is presently unknown. Efforts are being made, however, to try and link monetary values onto such natural habitat losses. Several academians have worked out systems for quantifying monetary values of wetlands (see, for example, Larson, ed., "Models for Assessment of Freshwater Wetlands" Univ. Mass Water Resource Research Center, Publication No. 32, 1976.) [Dawson, 1979]. It should be noted that this publication was not available during the development of this document. Numerous publications have been solely devoted to the theory of wetlands protection from pollution, and public/commercial development. Governmental concerns have been voiced through the July 31, 1986 hearing before the Senate Environmental and Public Works Subcommittee on Environmental Pollution at which questions were raised about the disagreement between EPA and the Corps of Engineers over the interpretation of regulatory requirements that overshadowed attempts to implement regulatory policies. The public and governmental opinions raised about wetlands and wetlands protection render a no standard policy nonviable.

The other alternative is a total ban standard. Although supported by many public and environmental interest groups, a total ban is too restrictive and raises numerous questions about the broad definition of wetlands for any type of effective and efficient policy to be promulgated. This alternative would require the removal of existing MSWLF units from wetlands that, according to many scientific opinions, cause more degradation to wetland resources than actually leaving the units intact. Their are numerous other issues associated with this standard that make it an impractical option for a feasible working standard.

D. FAULT AREAS

Earthquakes are part of the natural dynamics of the world. When they occur, they are usually catastrophes and all too often cause the loss of life and property. North Americans typically associate the west coast of the continent with areas of known seismic activity, but serious earthquake shocks have also occurred in and near the east coast [Legget and Karrow, 1983].

Earthquakes are usually caused by movements along faults. Faults are fractures in rock along which the adjacent rock surfaces are differentially displaced. Faults may vary in length from a few meters to many kilometers. The presence of faults indicate that at some time in the past, movement along the fault has occurred. Movement may be either a slow slip, that produces no ground motion, or a sudden rupture, that results in perceptible ground motion known as an earthquake [Bolt, 1978].

Movement along the fault plane is called the slip. Faults assume different geometric forms. Faults may be classified into three types; normal, reverse and strike-slip. A normal fault has movement down the dip of the rock, while a reverse or thrust fault has movement up the dip of the rock. Vertical displacements seen at the surface are produced by both normal and reverse faults. Therefore normal and reverse faults are generally referred to as dip-slip faults. A strike slip fault has a relative displacement, as viewed from the ground surface, that is at a right angle to the dip. This type of fault is sometimes referred to as a wrench or tear fault [Legget and Karrow, 1983].

When the displacement along a fault occurs, movements of great masses of material naturally develop dynamic effects of magnitude. The dynamic effects initiate vibrations or seismic waves within the earth's crust. The seismic waves travel for great distances in all directions, and it is because of these waves that a localized movement of the earth can have a disastrous effect over a wide area [Legget and Karrow, 1983].

The effects of earthquakes may cause the partial or total collapse of buildings, bridges, and tunnels, manmade and natural slopes may fail, and damage water or other types of distribution systems. The failure may be a result of the structures inability to withstand the ground motion or the foundation subgrade collapsing under seismic loading [Legget and Karrow, 1983].

The fracturing that faults represent is a normal part of the dynamic process of geologic development. Faults have occurred throughout the geologic time scale. Therefore, some are of great age, while others may be seen in Pleistocene deposits, being, correspondingly, very young in geologic terms. The age of a fault is related, in some ways, to its present character, (i.e., whether it is an active or a dead fault). These are very important characteristics of a fault, because it will indicate whether or not more movement on the fault is to be expected in the foreseeable future. The faintest possibility of movement taking place upon a fault plane under any engineering structure is one that has to be avoided at all costs, even to the extent of abandoning the proposed building site [Legget and Karrow, 1983].

In an earthquake, serious damage can arise, not only from the groundshaking but from the fault displacement itself. Although this particular earthquake hazard is very limited in area, it can usually be avoided by the simple expedient of obtaining geological advise on the location of active faults before construction is undertaken [Bolt, 1978].

Significant earthquakes thathave occurred in the United States include:

- The 1811-12 New Madrid, Missouri Earthquakes,

- The 1886 Charleston, South Carolina Earthquake,
- The 1906 San Francisco Earthquake, and
- The 1964 Good Friday Earthquake in Alaska.

Brief summaries of the 1811-1812 New Madrid, Missouri and 1906 San Francisco earthquakes are presented below.

Between December 16, 1811, and February 7, 1812, several major earthquakes devastated the midwest. The epicenters of the earthquakes were at New Madrid, Missouri, a small Mississippi river town in southeastern Missouri. The earthquakes, three total, each with an intensity of XII on the Modified Mercalli scale, knocked down chimneys as far away as Cincinnati, Ohio, Saint Louis, Missouri, and in many places in Tennessee and Kentucky. Bricks were reported to have fallen from chimneys in Georgia and South Carolina. The shock was felt from Canada to New Orleans, and from the headwaters of the Missouri river to the Atlantic, including Boston, 1,100 miles away [NOAA, 1973].

The most seriously affected area was characterized by raised and sunken lands, fissures, sinks, sand blows and large landslides. The area was 30,000 to 50,000 square miles in extent, from a point west of Cairo, Illinois to the latitude of Memphis, Tennessee, and from Crowleys Ridge to Chickasaw Bluffs, Tennessee, a distance of 50 miles [NOAA, 1973].

In spite of the great intensity of the earthquakes, the loss of life was insignificant because the area was sparsely populated. At New Madrid, only one life was lost. In other areas, several persons drowned when thrown into the river by caving banks, and a number of boatmen were lost when their boats sank [NOAA, 1973].

If an earthquake of similar intensity were to occur today at New Madrid, it has been estimated that the economic losses would be approximately $30 billion, translated into 1990 dollars. The estimated economic losses are comparable with the "worst case" estimates for a repeat of the 1906 San Francisco, California earthquake [USGS, 1981].

The April 18, 1906 San Francisco earthquake was one of the greatest known shocks in California. It was associated with the largest known slip along a fault plane in the contiguous United States. The observed extent of displacement on the fault was about 180 miles. The greatest slip was 21 feet in Marin County. The slip could be identified by the dislocation of fences and roads. Displacements of 10 to 15 feet were not uncommon. Minor rises of the ground surface, generally less than one foot and no greater than three feet, were observed in the region north of the Golden Gate Bridge [NOAA, 1973].

The area affected by the earthquake included most of California and parts of Nevada and Oregon. Buildings and structures in all parts of the city and county of San Francisco were damaged. Chimneys toppled, pavements were buckled, arched and fissured, brick and frame houses were severely damaged or destroyed, sewers and water mains were broken, and heavy streetcar tracks were bent into wavelike forms [NOAA, 1973].

The great shock and resulting fires caused damage estimated to be greater than $24 million and at least 700 deaths. A repeat of the earthquake probably would cause $30 billion in building damages, translated into 1990 dollars, and approximately 5000 deaths [USGS, 1981].

State Requirements

State regulations were reviewed by the Agency regarding seismic design requirements for MSWLFs. Of the regulations reviewed only Alabama and California have developed regulations restricting siting of MSWLFs over active faults. Alabama will allow siting if a site-specific evaluation demonstrates a minimum potential for adverse effects on water and the human health.

Impact of Siting in Fault Areas

The investigation of sites for the possible hazard of surface fault rupture is a deceptively difficult geologic task. Many active faults are complex, consisting of multiple breaks. Yet, the evidence for identifying active fault traces is generally subtle or obscure, and the distinction between active and long-inactive faults may be difficult to make. The California Division of Mines and Geology has developed a guideline for evaluating the hazard of surface fault rupture. The guideline outlines suggested investigative measures applicable to the detection, evaluation, and investigative measures applicable to the detection and evaluation of surface and near surface faults [California, 1975].

Fault rupture associated with earthquakes may cause damage to the MSWLF. Damage may include the rupture of the leachate collection and liner system. Failure of the leachate collection system may prevent the removal of the generated leachate, thereby allowing the leachate to "pond" on the liner. If the liner system is ruptured, this may create a pathway for leachate to migrate into and contaminate the uppermost aquifer. In addition to the potential damage to the leachate collection and liner systems, the integrity of the landfill slopes could also be impaired by fault rupture, resulting in the potential for exposing solid waste to surface runoff.

The general fault zone usually can be divided into a main fault zone, a branch fault zone, and a secondary fault zone. The spatial relationship of individual faults in the fault zone has resulted in this classification system. The main fault zone contains the main fault (i.e., the fault with the greatest displacement, length and continuity) and closely associated faults. The width of the main zone of faulting has been reported to range up to 3,000 feet, but in most of the cases (71-percent) the width was less than 1,600 feet and for half (50-percent) the width was less than 550 feet. Occasionally, faults diverge from and extend well beyond the main zone of faults and are referred to as branch faults. Secondary faults are completely separate spatially from the main fault and sometimes from several hundred feet to a few miles from the main fault. Associated with main, branch, or secondary faults are often small, subsurface faults evident as fault planes running parallel to the fault and typically are considered a part of that fault.

Adjacent to the fault rupture is commonly found a zone of deformation. This is an area where the ground has been bent or warped as a consequence of the two surface planes moving relative to one another. Surface deformation is frequently reported within a zone of several tens to several hundred feet wide. Structures located within this zone are subject to distortion and are likely to be subject to damage.

Standard

The Agency believes that MSWLFs may be affected by fault rupture and surface deformation resulting from an earthquake. To minimize the risk to MSWLFs by earthquakes, the revised Criteria states that new MSWLF units shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time. (The Holocene is a geologic time unit, known as an epoch, that extends from the end of the Pleistocene to the present and includes approximately the last 11,000 years).

Structures located across a fault at the time of surface faulting will be subject to fault displacement. The amount of and direction of displacement, and deformation will depend upon the type of fault (normal, reverse or strike slip) and amount of displacement (a few inches or feet to as much as 20 feet). The Agency believes that the best protection for MSWLFs is to avoid faults subject to displacement. The proposed regulation restricting locating a MSWLF within 200 feet (60 meters) of a Holocene fault typically covers the zone of deformation where the ground may be bent or warped as a consequence of the two surface planes moving relative to one another.

The Agency believes that prohibiting the location of new MSWLF unit within 200 feet of a Holocene fault, provides an adequate distance from the fault to protect the facility from surface faulting and the zone of deformation. In addition, by including this as a siting requirement for MSWLFs, the risk of leachate collection system and liner rupture due to surface faulting will be minimized. By minimizing the risk of rupture of the liner system and subsequent damage to the leachate collection system, the potential for contamination of ground water beneath the landfill will be reduced. The Agency's proposal also reduces the possibility that the integrity of the landfill slopes would be impared by fault rupture, resulting in the potential for exposing solid waste to surface runoff.

Alternatives

The Agency considered several alternatives for protecting MSWLFs from fault rupture. The alternatives included restricting the location of new MSWLF units over and within 100 feet (30 meters) of an active (Holocene) fault. Because the zone of deformation width of the fault zone varies, and that half (50-percent) are reported to be less than 550 feet, the Agency rejected the alternatives of restricting the location of a MSWLF over or within 100 feet of an active fault.

The Agency chose the other alternative considered, that restricts the location of new MSWLF units within 200 feet of an active Holocene fault. This standard is consistent with the 40 CFR 264.18(a) location standard requirements for hazardous waste treatment, storage and disposal facilities. The Agency believes that this location standard also is appropriate for MSWLFs because the concerns relating to failure of containment structures are the same for any landfill regardless of waste type and this standard will provide adequate protection for the facility from surface rupture and the zone of deformation.

E. SEISMIC IMPACT ZONES

Earthquakes are part of the natural dynamics of the world. When they occur, they are usually catastrophes and all too often cause severe impacts to human health and the environment. The movements of great masses of material naturally develop dynamic effects of magnitude that in turn initiate vibrations or seismic waves within the earths crust. The seismic waves (impacts) travel for great distances in all directions, and it is because of these waves that a localized movement of the earth can have a disastrous effect over a wide area [Legget and Karrow, 1983]. Seismic waves along with faults (see Section D, Fault Areas) are the primary cause of earthquake shock.

Geologic features can have a significant effect on the local effects of earthquake shock. Seismic waves travel at different speeds in different materials. Therefore, the effects of seismic waves in rock and unconsolidated material will be different [Legget and Karrow, 1983]. This can be demonstrated on Attachment 19 (Appendix A) by a comparison of the areas of equal intensity influenced by moderate and great earthquakes in the continental United States. As indicated larger areas are influenced in the eastern United States than in the western United States [USGS, 1981].

The effects of earthquakes may cause the partial or total collapse of buildings, bridges, and tunnels Man made and natural slopes may fail and damage water or other types of distribution systems. The failure may be a result of the structure's inability to withstand the ground motion or, the foundation subgrade collapsing under seismic loading [Legget and Karrow, 1983].

Significant earthquakes which have occurred in the United Stated include:

- The 1811-12 New Madrid, Missouri Earthquakes
- The 1886 Charleston, South Carolina Earthquake
- The 1906 San Francisco Earthquake
- The 1964 Good Friday Earthquake in Alaska

Brief summaries of the 1811-1812 New Madrid, Missouri and 1906 San Francisco earthquakes are provided in Section IV.D of this document.

Regional seismicity maps have been available since the 1950s to aid the engineer in reducing the effects of earthquakes on buildings and other structures. Regional seismicity or risk maps usually do not attempt to reflect geologic conditions nor take into account variations due to soil properties. The usefulness of the maps is not so much in the absolute values of acceleration mapped, but primarily because it provides insight into the relative hazard across the United States together with results concerning the relative importance of the various parameters involved [Algermission and Perkins, 1976; and Bolt et al., 1975].

A single parameter, such as a probablistic estimate of maximum acceleration, does not provide all of the information necessary to describe the characteristics of strong ground motion that are important in the design of structures. Nevertheless, a wide range of structures can and have been designed to be earthquake resistant using peak acceleration as the basic ground motion data [Algermission and Perkins, 1976].

The United States Geologic Survey published an open-file report addressing the probabilistic estimate of maximum acceleration in rock in the contiguous United States. The report presents maps of the relative earthquake hazard in various "seismic zones" of the continental UniteJ States based on a constant-probability level. Maps provided with the report identify the maximum horizontal accelerations in hard rock, expressed as a percentage of the Earth's gravitational pull (g), with a 90 percent probability that it will not be exceeded in 10, 50, and 250 years [Algermission and Perkins, 1982].

Another major cause of destruction during an earthquake is the failure of the ground structure by loss of strength that occurs in loose, saturated sandy soils. This phenomenon, termed liquification, is a result of an increase in pore water pressure. The increase in pore water pressure decreases, and sometimes eliminates the shear strength of the soil. Bodies of loose, relatively fine uniform sand below the water table are susceptible to liquification during an earthquake, especially if the duration of the quake is long enough for the occurrence of a large number of ossillations involving repeated reversals of shearing strains of large amplitude. Soil that has lost all shear strength behaves like a viscous fluid. Liquification often appears in the form of "sand fountains or boils" during earthquakes. When a soil fails in this manner, a structure resting on it simply sinks into it [Prakash, 1981; Terzaghi and Peck, 1967].

Liquification causes three types of ground failure: lateral spreads, flow failures, and loss of bearing strength. Lateral spreads involve the lateral movement of large blocks of soil as a result of liquification in a subsurface layer. Flow failures, consisting of liquified soil or blocks of intact material riding on a layer of liquified soil, are the most catastrophic type of ground failure caused by liquification. When the soil supporting a building or structure liquifies and loses its bearing strength, large deformations can occur within the soil, allowing the structure to settle and tip [USGS, 1981].

Ground motion associated with earthquakes may cause damage to the MSWLF. Damage may include the failure of dikes and berms, resulting in the exposure of solid waste, and/or rupture of the leachate collection and liner systems. Runoff could be contaminated by contact with the exposed solid waste, thereby creating the potential to contaminate surface water bodies. Failure of the leachate collection system may prevent the removal of the generated leachate, thereby allowing the leachate to "pond" on the liner. If the liner system is ruptured, this may create a pathway for leachate to migrate into and contaminate the uppermost aquifer.

Failure of natural and man-made slopes adjacent to the MSWLF may also affect the facility. Failure of these slopes may damage run-on and run-off control systems, leachate disposal/management systems, as well as reduce the stability of the containment structure berms.

State Requirements

State regulations were also reviewed by the Agency regarding seismic design requirements for MSWLFs. Of those reviewed, only California has developed regulations that stipulate that MSWLFs must be capable of withstanding the ground acceleration associated with an earthquake. The State of California requires that containment structures be capable of withstanding the maximum probable earthquake. The maximum probable earthquake, as defined by the California Division of Mines and Geology, as the maximum earthquake that is likely to occur during a 100-year interval. This earthquake is regarded as a probable occurrence, not as an assured event that will occur at a specific time [California, 1975].

California guidelines require that the following be considered when deriving the maximum probable earthquake [California, 1975]:

- The regional seismicity, considering the known past seismic activity.
- The fault or faults within a 100 kilometer radius that may be active within the next 100 years.
- The types of faults considered.
- The seismic reoccurrence factor for the area and faults (when known) within the 100 kilometer radius.
- The mathematic probability or statistical analysis of seismic activity associated with the faults within the 100 kilometer radius (the reoccurrence information should be ploted graphically).
- The postulated magnitude shall not be lower than the maximum that has occurred within historic time.

Impact of Siting in Seismic Impact Areas

Earthquakes can affect a waste management facility through ground motion, surface faulting, earthquake-induced ground failures and tsunamis. Although earthquakes cause much less economic loss annually in the United States than ground failures and floods, major earthquakes have the potential to cause sudden and great loss. Within minutes an earthquake can destroy or damage a waste management facility through ground motion, surface fault rupture, and earthquake-induced ground failures. These effects of an earthquake constitute one important set of the many important considerations in siting, designing, and construction of these critical structures [LARG, 1982].

Environmental media that may be contaminated by the failure of structures, tanks, etc., by ground motion include, air, ground water, surface water and soil. The pathway from the environmental media contamination to a public health or environmental damage may be direct or indirect. The possible health and environmental damage effects extend over a very wide range, depending on the waste technology employed, waste materials, the environmental transport and the mode of waste exposure to humans [LARG, 1982].

Locational Impacts

Earthquakes that occur near waste management facilities pose a risk to the public and the environment because the motion of the ground during destructive earthquakes have the potential to damage in-plant collection facilities, and waste-processing facilities, (e.g., landfills with protective engineering design and long-term surveillance). The most typical seismic related damage categories include:

- failure of structures, tanks, etc., due to a high level of ground motion,
- failure of structures, tanks, impoundments, and landfill containments due to soil liquefaction and liquefaction-induced landsliding and/or lurching, or, generally, extensive soil settlement,

- failure of structures, tanks, etc., due to fault rupture passing through structures, tanks, landfills, etc.,

- general landsliding, and

- failure of impoundments (dams, embankments, etc.).

Surface faulting, the permanent horizontal and/or vertical displacement of the ground, is one manifestation of a seismic event. Facilities located directly over a fault may be damaged due to rupture during the fault displacement (e.g., liner rupture). The rupture may result in an uncontrolled release of contaminants into the environment. The proposed requirements cited herein, were promulgated to prevent damage to MSWLFs from surface faulting.

The failure of natural and man-made slopes adjacent to waste management facilities may also have an affect. Failure of these slopes may damage run-on and run-off control systems, leachate disposal/management systems, as well as impact the facility containment structure(s).

Ground motion associated with earthquakes will have varying effects on the different types of waste management units. The effects will primarily be based on the materials used to construct the facility.

Berms and dikes, the primary structural components of landfills are typically constructed of earth. Damage to these facilities by ground motion may include slope failure of the dikes and berms, and differential settlement of the ground supporting the facility. These failures may result in the rupture or damage of the leachate collection and liner systems. Failure of the leachate collection system may prevent the removal of the generated leachate, thereby allowing the leachate to "pond" on the liner and prevent its removal. If the liner system is ruptured, this may create a pathway for leachate to migrate into and contaminate the uppermost aquifer. Runoff could be contaminated, by contact with waste exposed by the failure of dikes and berms, thereby creating the potential to contaminate soil and surface water bodies.

One of the major causes of destruction during an earthquake is the failure of the ground structure by loss of strength. This type of failure typically occurs in loose, saturated, cohesionl[illegible]s. This phenomenon, termed liquefaction, is a result of an increase in the soil pore water pressure, that decreases, and sometimes eliminates the shear strength of the soil.

Bodies of loose, relatively fine grained uniform sand below the water table are susceptible to liquefaction during an earthquake, especially if the duration of the quake is long enough for the occurrence of a large number of osillations involving repeated reversals of shearing strains of large amplitude. Soil that has lost all shear strength behaves like a viscous fluid and often appears in the form of "sand fountains or boils" during earthquakes. When a soil fails in this manner, a structure resting on it simply sinks into it [Prakash, 1981; Terzahgi and Peck, 1967].

Liquefaction causes three types of ground failure: lateral spreads, flow failures, and loss of bearing strength. Lateral spreads involve the lateral movement of large blocks of soil as a result of liquefaction in a subsurface layer. Flow failures, consisting of liquified soil or blocks of intact material riding on a layer of liquified soil, are the most catastrophic type of ground failure caused by liquefaction. When the soil supporting a building or structure liquefies and loses its bearing strength, large deformations can occur within the soil, allowing the structure to settle and tip [USGS, 1981].

Case Studies

Structural damages resulting from earthquakes have been extensively documented. The National Oceanic and Atmospheric Administration (NOAA) publishes an annual report titled "United States Earthquakes". This report lists all towns and cities reporting an earthquake, along with detailed descriptions of damage. Isoseismal maps are presented for earthquakes felt over extended distances. In addition, related information such as strong ground motion seismographic data, geodetic work of seismological interest, and fluctuations in well-water levels are also presented [NOAA, 1973].

Furthermore, NOAA published in 1973 "Earthquake History of the United States." This publication is a history of the prominent earthquakes in the United States from historical times through 1970. Detailed descriptions of damage, area affected, and other relevant information are presented for major earthquakes that have occurred in the United States.

Instances of past damages to human health and the environment are sometimes used as a justification for the promulgation of standards that are designed to prevent the future occurrence of such damages. For seismic impact zones it was difficult to find examples of waste management facilities that have been damaged solely by earthquake-induced ground motion. Many of the potential damages to waste management facilities, including MSWLFs, are obvious, or they can be deduced from past damages to similar structures during earthquakes. The adverse impacts of siting MSWLFs in seismic impact areas justifies the need for a comprehensive standard to prevent further releases of contaminants into the environment.

Standard

The Agency believes that MSWLFs may be affected by ground motion resulting from an earthquake. To minimize the risk to MSWLFs by earthquakes, all new MSWLF units located within a "seismic zone", with a 10-percent probability that the maximum horizontal acceleration in hard rock will exceed 0.10g in 250 years, must have all containment structures, including liners, leachate collection systems and surface water control systems, designed to resist the maximum horizontal acceleration for the "seismic zone".

This requirement translates to a four (4) percent probability of exceeding the maximum horizontal acceleration in 100 years. The Agency believes that the areas affected by the "seismic zone" requirement represents the areas of the United States with the greatest seismic risk. In addition, the Agency believes that the probability of exceedence and the range of horizontal accelerations requiring seismic consideration is acceptable, and that this requirement is protective of human health and the environment.

By including this restriction as a performance requirement for MSWLFs, the risk of slope and liner failure due to seismic activity is minimized. By minimizing the risk of failure of the landfill slopes, the potential for exposure of solid waste to the atmosphere and the possible contamination of runoff by contacting exposed solid waste will also be reduced. The potential for contamination of ground water beneath the landfill by failure of the liner will also be reduced by this requirement.

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In addition to designing the containment structure and all appurtenent facilities to resist the "seismic zone" requirement, no new units of a MSWLF shall be located in areas where inadequate support for the structural components of the landfill exists. The Agency considers soils with the potential for liquification, as discussed earlier, as an area of inadequate support. Therefore the owner or operator must determine if the proposed landfill site is susceptible to liquification. If the potential for liquification exists and protective measures cannot be incorporated into the design to prevent liquification, then the Agency will consider the site unstable. Unstable areas are further discussed in Section IV.F of this document.

Methods for Determining Seismic Risk

Numerous seismic design methods are available to the owner or operator to assess the proposed design of the landfill and appurtenances. The two most commonly used include the seismic coefficient method and the permanent displacement method. Both methods have been used to evaluate the design of embankments under seismic loading conditions.

The seismic coefficient method utilizes a static, horizontal inertial force applied to the potential sliding mass in an otherwise conventional static limit analysis. This method, commonly referred to as a conventional static stability analysis, represents the earthquake loading by a statically applied horizontal force. The seismic force is proportional to the weight of the potential sliding mass multiplied by the seismic coefficient, which is some fraction of the acceleration of gravity [Lambe and Whitman, 1969; Hynes-Griffin and Franklin, 1984].

The permanent displacement analysis was originally proposed by Newmark in his Rankin Lecture in 1965. The method estimates permanent displacement in an embankment due to seismic loading. A principle parameter in the analysis is the peak bed rock acceleration. This parameter must be determined by a site-specific risk assessment. The primary component of the method is the analysis of motions of a system consisting of a rigid block sliding on an inclined plane. If the base (i.e., inclined plane) is subjected to some sequence of acceleration pulses (the peak bed rock acceleration) large enough to induce sliding of the block, the result will be, after the motion has abated, that the block will come to rest at some displaced position down the slope. An embankment response analysis of the containment structure must also be performed. This dynamic analysis requires shear-wave velocities and damping values, consistent with expected strain levels, for all materials comprising the structure [Hynes-Griffen and Franklin, 1984].

The Department of the Army, Waterways Experiment Station published a miscellaneous paper outlining the procedures for performing a permanent displacement analysis. The paper presents figures and tables to assist in the analysis, as well as indicate situations where the procedure is not applicable [Hynes-Griffen and Franklin, 1984].

Alternatives

In addition to the standard discussed above, the Agency considered various alternatives for protecting MSWLFs from seismic motion. The first is a variation of the above standard and requires that new MSWLF units be designed to withstand the maximum horizontal accelerations in hard rock, expressed as a percentage of the Earth's gravitational pull (g), with a 90 percent probability that it will not be exceeded in 10 or 50 years in the contiguous United States.

A second alternative considered by the Agency consisted of performing a permanent displacement analysis of the containment structure. This method uses an idealized model of the displaced part of the embankment acting as a rigid block sliding on an included plane due to seismic motion.

A third alternative considered by the Agency would require all owners or operators of a MSWLF to conduct a detailed seismic risk assessment of the proposed landfill site. The seismic risk assessment would provide site-specific design parameters for the design of the landfill and appurtenances.

Of the alternatives considered, the 10 and 50 year risk maps were rejected based on the probability of exceeding the maximum horizontal acceleration identified. For the 10 and 50 year risk maps, the probability of exceeding the value identified in 100 years was 100 and 20 percent, respectively. The Agency considered the probability of exceedence too high, and unprotective of human health and the environment.

The Agency also rejected the alternative to require all owners or operators of a MSWLF to conduct a detailed seismic risk assessment of the proposed landfill site. This would require seismic risk assessments in areas of known minor or no seismic activity and would result in an additional expense to the regulated community that could not be justified.

The permanent displacement analysis considered by the Agency has not been rejected as a method to evaluate a MSWLF design to resist seismic motion. The Agency believes that due the lack of available information on the seismic response of solid waste, the procedure may be inapplicable at this time. But, as the state-of-the-art increases in the area of seismic design of MSWLFs, the Agency believes that conservative values of dynamic response, as well as strength properties for solid waste may be determined. Therefore, the Agency may consider a permanent displacement analysis as a method for evaluating a MSWLF design to resist seismic motion.

F. UNSTABLE AREAS

EPA has chosen to restrict the siting of MSWLFs in areas that are determined to be geologically unstable. EPA is proposing to require a demonstration of structural stability to be conducted by owners and operators of new and existing MSWLF units located in unstable areas. This demonstration must show that engineering measures have been incorporated into the design of the unit to mitigate the potential adverse impacts on the structural components of the unit that may result from destablizing events. These areas include landslide prone regions, karst terrains, subsidence-prone areas, and areas with comprehensive or expansive soils or ultra sensitive (quick) clays.

Landslide Prone Areas

Landslide is a general term covering a wide variety of mass-movement land forms and processes involving the downslope transport of soil and rock material under gravitational influence. They are a significant hazard in virtually every State. Although individual landslides are generally not as spectacular or as costly as some other geologic and hydrologic hazards, they are more widespread. Collectively, they cause major economic loss and casualties. In addition, landslides take place in conjunction with other hazards such as earthquakes, floods, and volcanoes [USGS, 1981].

Landslides can be classified on the basis of the type of movement and the type of material involved. The types of movement are falls, topples, slides, spreads, flows and combinations of two or more. The two classes of materials that are involved in landslides are bedrock and soils consisting of debris, earth or a combination of the two. Attachments 20 and 21 in Appendix A provide classifications, definitions and illustrations of the major types of landslides.

All landslides involve the failure of earth materials under shear stress. Consequently, any human activity or natural event that increases shear stress or lowers shear strength can trigger a landslide.

The major causes of landslides are [Winterkorn and Hsai-Yang, 1975]:

- Construction operations or erosion,
- Earthquakes and vibrations,
- Rains or melting snow,
- Freezing and thawing,
- Dry spells, and
- Seepage from manmade sources of water.

Construction operations or erosion can cause a landslide if they affect the support of a slope. Slides are common in excavated cuts for highways and railways and also in quarries and pits. Similarly, erosion of the toe (bottom) of a slope can leave the remaining slope face unsupported and subject to sliding. Heavy buildings located close to the edge of a slope can also contribute to the initiation of a slide.

Earthquakes and vibrations from blasting or construction related operations like pile driving can cause spontaneous liquifaction of loose sand, silt or loess deposits situated below the ground-water table. Under similar circumstances, some sensitive clays can undergo a decrease in shear strength. If the structures of these deposits collapse, the pore pressures increase and may approach the total overburden pressure. At this point, the shear strength of the soil is drastically reduced and the soil, behaving like a heavy liquid, flows down hill along with its overburden.

Rains or melting snows can cause increased pore water pressures leading to reduced shear strengths along potential slip faces. Most slope failures (landslides) occur after heavy rains or during spring snow melts when large quantities of water can penetrate cracks and fissures.

Freezing or thawing can induce cracking in rock formations resulting in rockslides. In silty soils, the freeze thaw cycle can cause increased pore pressures and consequently, ground surface movements.

The drying of soils may result in crack formation that can occur when overburden pressures are reduced as a result of reductions in soil water content. As a result of these cracks the shear strength can be reduced, increasing the chances of slides. Drying may also lead to the development of shrinkage cracks in shales, particularly in exposed formations.

Distribution of Landslides

Areas where landslides have been reported and landslide prone areas are shown on the map in Attachmant 22, Appendix A. Because of the map scale, only large areas are shown; small landslide prone areas that exist outside of the major areas are not shown on this map.

Areas in the Appalachian Mountains, Rocky Mountains, and the coastal ranges along the Pacific Ocean have the most severe landslide problems. All types of slope movements occur in these areas, including debris flows, the most dangerous form of slope movement with respect to human life. The large areas in the midcontinent region are underlain by relatively weak shales. In these areas, landsliding is prominent on moderate to steep slopes, and, because the materials are weak, large excavations commonly produce landslides even in flat areas.

Although not shown on the map, large parts of Alaska and Hawaii also are severely affected by landslides [USGS, 1981].

Expansive Soils

Certain types of soils and soft rocks will expand when they become wet and shrink when they dry out. The extent of the damage caused by this behavior is attested by the fact that estimates of damages to houses, commercial buildings and streets, buried utilities and other structures ran as high as 7 billion dollars per year in 1980.

Swelling or expansive soils are generally rich in clay minerals, particularly smectites (montmorillonites). These minerals swell by adsorbing water that enters and expands the space between the plates that constitute the crystaline structure of the clay mineral. The process is reversible and, upon drying, the spacing decreases and the clay shrinks. Montmorillonite clays are the most prone to this behavior with bentonite clay being an extreme case that can increase in volume by a factor of 10 as it goes from its dry to its saturated state.

Expansive soils are widely distributed world wide. Their distribution in the United States is shown on the map in Attachment 23, Appendix A. Smectites are most abundant in geological formations throughout the Rocky Mountains, in the upper great plains, in the southern gulf coast plain and along the Pacific Coast. They are also locally abundant throughout the great basin region, and along the Atlantic Coast.

The amount of expansion that can occur depends on the type and quantity of clay mineral present, and is a function of time, confining load (weight of material, resting on top of the expansive clay), initial density and initial water content [U.S. Department of Interior, 1974]. The relationships between confining load and expansion, for two clays, is shown in Attachment 24, Appendix A. Expansive clay formations that, in nature, do not exhibit excessive shrink swell activity, can become a problem as a result of construction activities that remove overburden (reduce confining load) or allow greater access of water to the formation.

If adequate precautions are not taken during construction, expansive soils can cause severe damage to many types of structures. Attachment 25 in Appendix A shows damage to canal liners that occurred as a result of the expansion of clay soils below the structures. In similar situations, MSWLF liners built to contain leachates or runoff would be similarly damaged and thereby rendered useless for their intended purpose.

Subsidence

Subsidence is defined as the lowering or collapse of the land surface either locally or over broad regional areas [USGS, 1981]. Subsidence can be the result of either natural phenomena or human activities.

Natural causes of subsidence include disolution of limestone and other soluble materials, earthquakes and volcanic activity. Limestone and Dolomite are slightly soluble in water and, especially in hot and wet climates, the solution process can cause voids to form in formations of these minerals. If overlying materials collapse or subside into the solution cavities a surface depression, called a sink-hole, will form. Where limestone or dolomite deposits are widespread and sink-holes are common, the land surface is referred to as karst topography or karst terrains after a district in Yugoslavia where the phenomenan is common [Bolt et al., 1975].

Sinkholes vary in depth from slight indentations to over 100 feet deep. Typically, depths range from 10 to 30 feet with areas in the range of a few square yards to several acres. There are two major classes of sinkholes. The first type forms from the collapse of an underground void. The more common type, the doline, develops slowly by the downward solution of the underlying rock. Surface water entering the first type of sinkhole tends to flow rapidly underground through outlets called swallow holes. Runoff draining into a doline usually percolates slowly underground through the soil in the bottom of the sinkhole. If a sinkhole becomes clogged, a temporary pond or lake will form. If the outlet is unplugged, rapid drainage may occur. This was the case at Lake Jackson, a lake of approximately 25 square kilometers near Tallahassee, Florida, that drained on May 22, 1982.

The major locations of karst terrain and caverns in the United States, as shown by the maps, (Attachments 26 and 27 Appendix A) are in parts of many of the Southeastern and Midwestern States. Sinkholes also are found in some of the Western and Northeastern States. Alabama, where soluble limestone and other rocks are present in nearly one-half of the State, has thousands of sinkholes that pose serious problems for highways and construction.

Earthquake-related subsidence has taken place mainly in Alaska, California, and Hawaii and to a lesser extent in other States. This type of subsidence can result from vertical movement of faults and may effect broad areas. This process took place in 1964 in southern Alaska in conjunction with the Prince William Sound, Alaska, earthquake. More than 70,000 square miles were tilted downward more than 3 feet and subsequently flooded. Subsidence resulting from intense earthquake ground shaking involves somewhat smaller areas than that resulting from regional vertical faulting. Intense ground shaking generated during the 1811-12 New Madrid, Missouri, earthquakes caused subsurface sand and water to be ejected to the surface. This ejection left voids in the subsurface, causing local compaction of subsurface materials and settling of the ground.

Volcanic-related subsidence is a potential problem in parts of Alaska, California, Hawaii, Oregon, and Washington. Subsidence usually is caused by local collapses above shallow tunnels formed by flows of lava. Collapses over much broader areas can also occur as magma chambers are emptied by volcanic eruptions [USGS, 1981].

The human activities that cause subsidence are the withdrawal of water, oil or gas from subsurface formations. When in place, these materials fill the pore spaces in the formation and bear some of the stress of the overburden. When the fluids are removed, by pumping, the effective stress on the formation increases as the pore pressure decreases. This can cause the formation to compress vertically with the result that the land surface subsides.

The most dramatic examples of subsidence caused by withdrawal of oil, gas, and water are along the Gulf Coast of Texas, in Arizona, and in California. The harbor at Long Beach, California, has subsided as much as 27 feet from withdrawal of gas and oil. The Houston-Galveston area of Texas has experienced as much as 7.5 feet of subsidence locally. An area of about 2,500 square miles has subsided 1 foot or more. Subsidence in the Houston-Galveston area appears to have been caused mainly by the withdrawal of large amounts of ground water, although some areas of local subsidence have bee[illegible]sed by the extraction of gas and oil. Coastal towns in

Texas, such as Baytown and Seabrook, have subsided about 3 feet and are now susceptible to flooding from storm surges and hurricanes [USGS, 1981].

Recent research suggests that subsidence caused by withdrawal of ground water can also cause fissuring or renewal of surface movement in some areas cut by preexisting faults. Fissuring is the formation of open cracks. Surface faulting and fissuring associated with withdrawal of ground water are believed to have either taken place or to be a potential problem in the vicinity of Las Vegas, Nevada, as well as in parts of Arizona, California, Texas, and New Mexico [USGS, 1981].

The removal of solid materials from underground deposits can also result in subsidence. This is especially true of shallow coal mines where adequate roof support was not provided and collapses occured either during mining or long after mining has ceased.

Subsidence in areas of underground mining has caused hazardous conditions in parts of Pennsylvania and other Appalachian States, Colorado, North Dakota, Wyoming, New Mexico, Washington, Iowa, and Illinois. Subsidence-related damage to surface structures is common in the area around Pittsburgh, Pennsylvania, where coal has been mined extensively. Subsidence depressions and pits, forming above abandoned underground mines, are a hazard in the Sheridan, Wyoming, area.

Solution mining also can cause subsidence. In solution mining, water-soluble minerals such as salt, gypsum, and potash are dissolved and pumped to the surface so that the water can be evaporated. Huge underground cavities are formed, causing surface subsidence. Examples of this hazard, whose locations are not well known, include the sudden collapse of a street at Grand Saline, Texas, in 1976, into an abandoned salt mine cavity created between 1924 and 1949, the subsidence in 1974 near Hutchinson, Kansas, and subsidence in 1971 near Detroit, Michigan [USGS, 1981].

With some soils and soft rock formations, the addition of water can cause subsidence. One type of formation where this can happen is called loess. This material has the characteristics of soft rock being formed from fine grained material cemented together in an extremely loose, open structure by a water soluble mineral cement. In the dry state loess is firm and hard and serves well as a foundation material. When subjected to excessive wetting from sprinking or ponding on the surface, the mineral cement is dissolved away and the soil structure collapses in the area where the wetting has occurred.

Hydrocompaction, or the settling of sediments after water is added, is another significant cause of subsidence, especially in the arid to semiarid Western and Midwestern States. The areas of known compaction include the San Joaquin Valley, California; Heart Mountain-Chapman Beach and Riverton, Wyoming areas; Hysham Bench, Montana; Columbia Basin, Washington; Denver, Colorado; Washington-Hurricane area in southwest Utah and central Utah; and, the Missouri River Basin. Hydrocompaction takes place when dry surface or subsurface deposits are extensively wetted for the first time since their deposition as, for example, when arid land is irrigated for crop production or an irrigation canal is built on loose dry uncompacted sediments. Wetting causes a reduction in the cohesion between sediment grains, allowing the grains to move and to fill in the naturally occurring intergranular openings. The result is a lowering of the land surface from 3 to 6 feet, although subsidence of as much as 15 feet has been recorded. The effects of hydrocompaction on the land are usually uneven, causing depressions, cracks, and wavy surfaces. As a result, canals, highways, pipelines, buildings, and other structures can be seriously damaged [USGS, 1981].

Potential Impacts of Unstable Areas

To meet the performance standards set for protecting ground water from pollution by MSWLF leachate, landfills must be lined or placed in areas with naturally low permeabilities. The long term maintenance of the integrity of a liner, whether it is synthetic (FML) or constructed of recompacted clays, requires a firm, secure foundation that provides even support beyond the active life of the facility. Liner and leachate collection system integrity can be disrupted in areas of unstable terrain if proper care is not exercised in site selection and facility design and construction.

In landslide prone areas, construction on natural slopes could cause problems if the placement of waste overburden leads to a situation in which the shear strength of underlying materials are exceeded. Another possibility is that vibrations generated by construction equipment and heavy vehicular traffic on the site could trigger ground movement. In unstable areas where liners are being constructed, care must be taken to avoid removing the toe of adjacent slopes that could slide into the landfill and damage the liner and leachate collection system.

In areas with expansive clay, liners can be torn or rocked and sidewalls can collapse if uneven expansion and bulging takes place below the facility liner. These phenomena have been reported for canal liners similar to MSWLF liners in that both are constructed to minimize liquid loss from the facility. Expansive soils can be treated in situ, removed from the site or sealed to prevent changes in their moisture content. If expansive clays soils are deep enough, sufficient overburden can be left in place to prevent excessive swelling. Regardless of the solution chosen, the problem must be recognized early in the planning stage in order to include proper expansive soil control measures in the facility design.

In areas that are plagued with subsidence problems associated with the presence of underground cavities there is always the very real possibility that a subsidence event will occur below a MSWLF. This is especially true if the weight of the placed waste exceeds the bearing strength of the materials supporting the facility. Collapse of the substrata would be catastrophic in that liner integrity would be destroyed, perhaps irreparably.

The Agency examined case studies and documented events that cited the types of environmental problems resulting from locating waste management units in unstable areas. The problems associated with differential or total foundation movement, loss of facility structural integrity, sudden and/or emergency release of contaminants, difficult and costly corrective actions, and releases attributed to poor maintenance or inadequate facility design, make the locating of MSWLFs in unstable areas a poor alternative. The Agency believes that it is essential for the owner or operator to extensively evaluate the adequacy of the subsurface foundation support for the structural components of the landfill.

Some documented events of structural problems associated with subsidence, collapse and heave in unstable areas that the Agency evaluated in developing this standard illustrate the above cited inadequacies of locating waste management units in these types of areas.

In Houston, Texas, a dècline in the water table over the last hundred years has caused as much as 8.9 feet of subsidence with serous surface effects.

Oil extraction over a fifty-year period in Long Beach, California caused up to 29.5 feet of subsidence with serious efffects.

Ground subsidence from mining operations has occurred in about 30 states, primarily in Pennsylvania, Kansas, Missouri, Oklahoma, Montana, New Jersey, and Washington. Severe structural problems have been reported in the Scranton-Wilkes Barre and Pittsburgh areas of Pennsylvania.

Ground collapse over soluble rocks has caused destruction of houses in central Florida, settlement of a seven-story garage in Knoxville, Tennessee, and a foundation and structural failure in an Akron, Ohio department store that resulted in loss of life.

In Menlo Park, California, a large urban development suffered substantial and costly damage from the expansion of clay shales.

The following case studies also document the problems associated with these areas.

Case Study 1

An unknown quantity of industrial waste believed to be from a refinery process was dumped on a six-acre peninsula near Houston, Texas. The site is bordered on the south and west by the San Jacinto River, on the north by a wooded area, and on the east by Clear Lake and a sand pit. The site is situated within a ten-year floodplain and has subsided two and a half feet since 1964 due to extensive ground-water withdrawals in the Houston area. The site is located on the banks of the San Jacinto River and is geologically situated within recent alluvial sediments (upper sand). The thickness of this layer is approximately twenty-three feet. Below the upper sand is a Beaumont clay layer with an average thickness of 30 feet. Another sand layer (middle sand), twenty-five feet in thickness, underlies the clay layer. Below the middle sand is a twenty-five foot clay interval with another sand layer sixteen feet in thickness beneath the clay. The contamination of the site spread in two ways; one by leaching through the subsurface due to subsidence of the land. Small channels and earth movements allowed the waste to migrate into the shallow aquifer that is not used for drinking water, but flows into surface water. The other way was a flood in 1961 that eroded some of the surface and induced a minor washout of the acid pit that deposited waste directly into the surrounding surface waters.

The corrective action that must be implemented is source control. The source must be removed and, due to the possibility of more subsidence, all remedial alternatives that employ on-site disposal or landfill have been determined to be unsafe for human health. The contamination has not yet spread to dangerous levels and removal of the source will prevent that from ever occurring as long as the waste is disposed of offsite. The main concern of the site is exposure of the waste to the hydrologic system. The upper ground water has been contaminated to the point where the water is unfit for any practical purpose. This ground water is seeping into highly utilized surface waters. However, no measurable impact has yet been found. Also, floods are capable of washing waste materials directly into the San Jacinto River system or continued subsidence will allow the water table to rise into the waste material increasing the contaminant discharge to the surface water [Draft Case Studies, Tetra Tech, 1987b].

Case Study 2

A municipal/industrial landfill in Madison County, Florida was located adjacent to two karst paleosinks, ancient sinkholes buried beneath recent surface deposits. The soil beneath the landfill consisted of a thin sand layer over clay sediments between 50 and 100 feet thick. However, the clay layer pinches out laterally near the sinks and is replaced by a sandy clay. The direct contact between the waterbearing limestone formation and overlying sands in the karst paleosinks provided a fairly unrestricted vertical migration pathway for landfill leachate. The highly transmissive rubble zone on top of the upper limestone contributed to rapid horizontal migration of contaminants. A variety of VOCs were detected in downgradient domestic wells.

Corrective action consisted of removing drums from the two burial sites to a hazardous waste landfill. Water purifiers were installed in the contaminated domestic wells to prevent exposure to contaminated drinking water. A remedial investigation and feasibility study have been proposed but have not yet been initiated [Draft Case Studies, Tetra Tech, 1987b].

Case Study 3

Sinkhole collapses in each of four hazardous waste surface impoundments containing a ferric chloride solution occurred at an electronics manufacturing plant in northern Puerto Rico between 1978 and 1981. As a result, approximately 1.4 million gallons of the solution were released into the underlying karst. Laboratory studies indicated that the wastes reacted with the calcite limestone to form a nonhazardous precipitate. Ground-water sampling in the area seems to support this theory as no contamination has been detected. However, soil borings in the soil and limestone beneath the impoundments showed elevated levels of iron.

Corrective action has included replacement of the surface impoundments with two aboveground holding tanks within a concrete diked area. The ferric chloride solution is currently being shipped to the U.S. for use as a flocculating agent for industrial and wastewater treatment. Also, the main subsurface solution channel beneath the site was filled with cement grout in 1983 to increase the structural support of the subsurface [Draft Case Studies, Tetra Tech, 1987b].

Case Study 4

Leachate from a municipal/industrial landfill in Florida moved rapidly along solution cavities and lineaments causing a non-uniform spread of contaminants south of the landfill. The underlying geology is a highly weathered series of sand and clay strata between 20 and 70 feet thick overlying weathered limestone. Contamination was detected in downgradient wells over an area of 100 acres four years after operation began.

Corrective actions were implemented at the site. An impermeable clay cap was placed over the landfill to reduce infiltration and therefore leachate production. The local surface drainage was altered to minimize contact with the fill. The facility operators have also provided a public water supply to residents in the contaminated area [Draft Case Studies, Tetra Tech, 1987b].

Case Study Summary

The example case studies and documented events illustrate that potential for release of wastes in unstable areas, the common release pathways and potential impacts associated with these releases. These case studies attribute the release of waste either by being located in unstable areas (e.g., karst, subsidence prone, etc.) or due to poor maintenance or inadequate facility design. All of the releases illustrate the problems of locating waste management units in unstable areas and associated waste impacts including: (1) rapid dispersion of contaminants over a large area; (2) potential human-health effects caused by the contamination of municipal water supplies, basement seepage pathways, and ground-water contamination; and (3) inability to accurately detect or monitor releases.

Corrective actions associated with construction of structures in unstable soil or rock areas can be difficult, if not impossible, to accomplish and certainly too expensive to finance unless conducted within the framework of a well-planned, fully integrated, professional geotechnical investigation, design, and construction quality assurance program.

Settlement, expansion or stability analyses can be made using data obtained from site investigation programs that include topographic and location surveys, exploratory borings, ground-water monitoring, air photo interpretations, in-situ testing, and geophysical surveys. These analyses can incorporate appropriate factors of safety and provide the necessary degree of protection to the public and the environment from specific geologic hazardous and the risks associated with contaminant releases.

Slope failures and ground movement must be evaluated in terms of the degree of the hazard and the risk to human life and the environment when facilities are sited. Some existing geologic conditions and physical settings cannot be improved and therefore should be avoided; while others allow the hazard and asociated risk to be reduced or eliminated through proper site analysis, design and construction technique. Associated quality assurance or quality control activities during construction become a necessary requirement, if future problems are to be avoided.

Standard

The proposed standard requires owners or operators of new and existing MSWLF units to provide an adequate design demonstration when siting MSWLFs in "areas where inadequate foundation support for the structural components of the landfill exists." While such foundation support conditions may be common over large areas of the country there will be places within these regions where MSWLFs may be safely sited.

For the most part, identification of MSWLF sites in unstable areas will have to take place on a case-by-case basis because geographic delineation of these areas is not possible on a national scale. National maps are available describing Karst terrains and landslide-susceptible areas, but weak and unstable soils and subsidence-prone areas appear to be mapped only individually or at the local level. An estimated 4% of all MSWLFs are in Karst terrain.

Under the proposed requirement, the facility owner or operator will be responsible for determining if the unit is located in an area that is subject to the events that may cause or contribute to facility failure. If the unit is located in such an area, it is the owner's or operator's responsibility to demonstrate that the proposed site is not subject to destabilizing events. EPA has chosen to require this method (that is, demonstration of no effect) because of the difficulty in clearly delineating unstable areas on a broad scale. A case-by-case decision-making approach offers the soundest results under the circumstances. For example, a facility may be located in an area where Karst features generally are known to exist. The particular facility location may not exhibit the destabilizing Karst features that result in subsidence. In this case, the owner or operator should be able to demonstrate to the State that the facility will not be destabilized by the location.

Alternatives

There were three alternative approaches that the Agency considered for regulating the siting of MSWLFs in unstable areas. These were:

1) No standard relating to the siting of MSWLFs in unstable areas.

2) Develop detailed maps of all unstable areas and prohibit siting of MSWLFs in those areas.

3) Require demonstrations by all owner/operator that site is not subject to damage from unstable conditions.

The first alternative was the simplest and least costly to implement; however, it was the least protective of the environment and human health.

The second alternative, to map all unstable areas and ban MSWLFs from these areas, was clearly unworkable. Many unstable areas cover large geographic areas and to ban the placement of MSWLFs within these areas would impose a great economic burden on communities located in those areas. Additionally the task of mapping all unstable areas with sufficient detail and accuracy is probably beyond the capabilities of modern geosciences, as well as too costly to receive serious consideration.

The third alternative provides the best approach to controlling the siting of MSWLFs. Owners/operators would be required to do a geotechnical study of all proposed sites in order to demonstrate that unstable conditions do not exist. This would allow the placement of facilities within broad geographic areas where unstable conditions may potentially exist while at the same time prohibit the placement of a facility on a specific site where unstable conditions actually do exist.

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APPENDIX A

ATTACHMENTS FOR SECTION IV

Attachment I
(Source: FAA, 1987)

SUMMARY OF SERIOUS BIRD STRIKES

CIVIL AVIATION

This summary provides information on reported serious bird strikes worldwide. Data sources include National Transportation Safety Board summaries, International Civil Aviation Organization bird strike reports, summaries prepared by the Bird Strike Committee Europe, and data from the Federal Aviation Administration (FAA) Bird Strike/Incident Report, FAA Form 5200-7. Serious bird strikes are those collisions between aircraft and birds where one or more of the following occurs:

a. Injury or loss of life;
b. Loss of aircraft;
c. Damage/loss/shutdown of more than one engine on multiengine aircraft;
d. Uncontained engine failure;
e. Fire;
f. Penetration of the bird through the airframe;
g. Major structural damage; and/or
h. Particularly unusual or dangerous features (obscuration of visibility, helicopter rotor or transmission damage, damage to pitot-static systems, etc.).

Details on accidents/incidents are provided, where available, to amplify the seriousness or significance of the bird strike.

April 3, 1912 - Model EX Wright Pusher, Long Beach, California - Bird strike hazard history was made on this date with the crash of the Wright Flyer and the death of Calbraith Perry Rodgers. This first reported crash and fatality occurred as Cal Rodgers was flying low along the beach and hit a gull, causing the aircraft to plunge into the ocean. The pilot was pinned under the wreckage and drowned. One fatality.

About 1955 - Light Aircraft, Aberdare Mountains, Kenya - Aircraft hit a vulture during enroute phase of flight and crashed. One fatality.

January 10, 1959 - Light Aircraft Serengeti National Park, Tanganyika - Aircraft struck a vulture and crashed. One fatality.

March 10, 1960 - Air Carrier Lockheed Electra, Boston, Massachusetts - Aircraft hit a flock of starlings resulting in engine power loss. Aircraft crashed with 62 fatalities.

July 15, 1962 - Air Carrier DC-3, Lahore, West Pakistan - Copilot killed when vulture penetrated windshield. Aircraft landed safely by injured pilot. One fatality.

September 1962 - Air Carrier Vanguard, Edinburgh, Scotland - On takeoff from Turnhouse Airport, aircraft encountered a flock of gulls. NR 2 and NR 4 engines failed, NR 3 engine damaged, but pilot made a successful landing with no injuries.

November 23, 1962 - Air Carrier Viscount, Maryland - Enroute aircraft encountered flock of whistling swans and struck one, resulting in loss of aircraft control. Aircraft crashed with 17 fatalities.

March 1963 - Beechcraft Enroute Over California - Aircraft struck common loon and crashed. One fatality.

February 1964 - Turbulent, Belfast Northern Ireland - Aircraft hit a gull and crashed. One fatality.

July 28, 1963 - Commercial Air Taxi Falcon, Cleveland, Ohio - On takeoff from Burke Lakefront Airport, aircraft hit a flock of birds causing failure of both engines due to flameout; aircraft subsequently crashed in the lake. Three crewmen injured.

November 17, 1968 - Beechcraft 95, Hamilton, Illinois - Aircraft collided with a goose, breaking windshield. Pilot made a forced landing.

November 20, 1968 - Business Beechcraft 95, Cairo, Illinois - Enroute aircraft hit a flock of geese with substantial damage to the vertical stabilizer. Aircraft made a safe landing with no injuries.

January 12, 1969 - Air Carrier B-707, Sydney, Australia - Takeoff aborted after V_1 due to partial power loss caused by bird injestion. Aircraft gear collapsed after leaving the runway. Crew of 11 with 125 passengers, no significant injuries.

March 11, 1969 - Air Taxi Bell 45 Helicopter, Tularosa, New Mexico - Tail rotor separated in flight after hitting eagle. Autorotative landing made, no injuries, aircraft substantially damaged.

October 13, 1969 - Piper PA-23, De Moines, Iowa - Aircraft struck a flock of large birds at 3,500 feet MSL. Pilot made a forced landing at Des Moines after aircraft experienced flight control difficulties and substantial structural damage.

March 12, 1970 - Cessna 150, OpaLocka, Florida - On student pilot's first solo, the aircraft struck a flock of gulls on takeoff. The windshield was broken and pilot attempted a forced landing resulting in substantial aircraft damage.

August 3, 1970 - Hughes 269B Helicopter, Big Rock, Virginia - The helicopter hit a bird and while the pilot was checking for damage, he allowed the helicopter to descend and strike a powerline. The helicopter crashed and the pilot sustained serious injuries.

November 11, 1970 - Bellanca 14 Flight Test, Santa Rosa, California - Aircraft's right wing hit a turkey vulture, causing substantial damage to wing. Aircraft landed without further incident.

July 2, 1971 - Cessna 180, British Columbia - An enroute bird strike with a bald eagle caused the aircraft to crash. Three fatalities.

August 18, 1971 - Air Carrier DC-9, Savannah, Georgia - During climb, aircraft hit a black vulture. The bird broke the radome and penetrated the pressure bulkhead and into the cockpit. Precautionary landing made with no injuries to 5 crew and 56 passengers.

September 9, 1971 - Cessna 180, Minot, North Dakota - On landing approach, aircraft hit two gulls diverting attention of pilot resulting in hard landing, gear collapse, and ground loop. Aircraft destroyed and pilot received minor injuries.

March 26, 1972 - Piper PA-28, Lower Lake, California - On final approach, aircraft hit an owl, puncturing leading edge of right wing resulting in loss of fuel. Aircraft landed with no further incidents.

April 16, 1972 - Mitsubishi MU-2, Atlantic City, New Jersey - On climb, the aircraft hit a flock of geese, breaking the windshield and incapacitating one or both pilots. Aircraft entered an uncontrolled descent and crashed in the Atlantic Ocean. Two crew and one passenger killed.

October 22, 1972 - Cessna 175, Miami, Florida - On descent for landing, aircraft hit a black vulture causing damage to the wing. Airflow over wing was altered sufficiently to cause a significant increase in stall speed.

December 15, 1972 - Air Carrier B-747, Miami, Florida - On takeoff, pilot experienced excessive vibration in NR 4 engine and shut the engine down, returning to land. Aircraft also had a bird injestion on NR 3 engine, jamming thrust reverser mechanism. Upon landing on a wet runway, the aircraft hydroplaned, braking and reverse thrust were ineffective. Aircraft rolled beyond the end of the runway and the gear collapsed. Crew of 11 and 149 passengers escaped without injury.

February 2, 1973 - Bell 206B Helicopter, Lake Charles, Louisiana - During cruise the helicopter hit a black vulture which jammed between the transmission and the swash plate, and the cyclic control tube was broken. A power-off autorotative landing was made resulting in substantial damage because of a hard landing.

February 26, 1973 - Learjet Atlanta, Georgia - Aircraft departed Peachtree-Dekalb Airport and struck a flock of brown-headed cowbirds resulting in complete failure of one engine and partial power loss on the remaining engine. Aircraft crashed killing two crew, five passengers, and one person on the ground. The aircraft was destroyed.

July 31, 1973 - Aerial Spray Callair A-9A, Grygla, Minnesota - Aircraft struck a sandhill crane during a spray swath, damaged the right aileron, and the pilot was unable to maintain aircraft control. Aircraft was destroyed and pilot seriously injured.

November 7, 1973 - Piper PA 32, Corpus Christi, Texas - Aircraft collided with large flock of birds while climbing through 4,000 feet above ground requiring an emergency landing. Aircraft sustained substantial airframe skin damage.

August 22, 1974 - American Avco AA5, Enroute Near Homestead, Florida - Aircraft hit a bird at 500 feet above ground level and the aircraft hit a tree after momentary loss of control. Aircraft damaged during crash landing.

October 16, 1974 - Cessna 500, New Haven, Connecticut - During takeoff from Tweed-New Haven Airport, the aircraft injested gulls in the NR 1 engine. Takeoff was aborted. Aircraft hydroplaned and left the runway, hitting a ditch and destroying the aircraft. Two crew and one passenger escaped without injury.

January 26, 1975, Pushpak Trainer, Patalia, India - Aircraft was in the traffic pattern when it struck a vulture. The wing strut was damaged causing loss of control. The aircraft was destroyed on impact.

April 12, 1975 - Piper PA-30, Iowa City, Iowa - Aircraft was in the traffic pattern, hit a flock of ducks causing substantial airframe damage.

June 14, 1975 - North American NA-265, Watertown, South Dakota - Aircraft hit a flock of gulls on takeoff resulting in complete loss of power due to flame-outs on both engines. Aircraft wingtip contacted instrument approach light T bar stand before crashing off the end of the runway. Two crew and one passenger seriously injured, three other passengers sustained minor injury.

November 12, 1975 - Air Carrier DC-10, J. F. Kennedy Airport, New York - On takeoff roll, the DC-10 injested gulls into the NR 3 engine resulting in engine fire and engine disintegration. Aircraft aborted takeoff but was unable to use thrust reversers and hydraulic failure occurred. Aircraft was destroyed by fire. Two of eleven crew seriously injured, 128 passengers escaped without injury. The low number of injuries was attributed to rapid evacuation. The majority of the passengers were airline flight attendants.

January 26, 1976 - Cessna 150, Bath, South Carolina - While enroute, aircraft hit a hawk, shattering the windshield. Pilot made a forced landing in an open field and hit tree stumps causing substantial damage to aircraft. Pilot and passenger sustained minor injuries.

February 13, 1976 - Air Carrier B-747, Orly Paris, France - During takeoff, gulls were struck after V_1 with birds being injested into NR 1 and NR 4 engines. Takeoff was continued, fuel was jettisoned, and aircraft landed. NR 1 engine sustained major damage, NR 4 required replacement of fan blades.

[illegible] - [illegible] Hughes [illegible] - [illegible] spray swath run, a bird struck the spray boom brace, and the brace hit the tail boom. Aircraft crashed causing significant damage. Pilot was not injured.

June 12, 1976 - Cessna 210, McMinnville, Oregon - During cruise, bird impacted nose gear doors and jammed the doors in the closed position. Aircraft landed gear-up causing substantial damage to lower nose cowling.

August 27, 1976 - Air Carrier B-747, Hong Kong - At 400 feet on takeoff, two large birds passed under the right wing. A 13 by 6-inch hole was found in the flap canoe fairing outboard of the NR 3 engine. Remains of a small hawk were found.

September 4, 1976 - Cessna 150, Luton, United Kingdom - Aircraft hit a flock of pigeons with damage to the propeller and windshield. Pilot made a forced landing following engine shutdown.

November 12, 1976 - Falcon 20, Naples, Florida - Before the aircraft departed, airport personnel dispersed birds from the airport. Approximately 30 birds circled the airport and the departing aircraft struck these birds on takeoff. Both engines failed and aircraft made a forced landing off the airport. Two crew and nine passengers were seriously injured on impact. Gulls identified as ring-billed gulls.

January 14, 1977 - Air Carrier DC-8, Amsterdam, Netherlands - On takeoff, aircraft struck a flock of gulls and injested birds into NR 1 and NR 2 engines, requiring immediate shutdown of NR 2 engine. Fuel was jettisoned and aircraft returned for landing.

February 10, 1977 - Piper PA-28, Nottingham, United Kingdom - During climbout, aircraft struck a flock of lapwings breaking the windshield and causing facial lacerations to the pilot. A safe landing was made.

April 7, 1977 - Piper PA-23, Glasgow, United Kingdom - At 3,000 feet above ground level and 160 knots, the aircraft struck a less black-backed gull causing a 12-inch diameter hole in the wing leading edge. Aircraft landed without further incident.

April 14, 1977 - Cessna 150, Atlanta, Georgia - On a local flight, aircraft hit a hawk, windshield was destroyed, and aircraft landed without further incident. One crewman seriously injured, other crewman received minor lacerations.

April 23, 1977 - Aero Commander, Chicago, Illinois - Pilot was advised of birds on the runway at Meigs Field. Pilot took off into a flock of birds, injesting gulls in one engine. Aircraft emergency procedures were improperly executed and aircraft entered a spin and crashed in the water, killing the pilot and three passengers.

April 25, 1977 - Hiller 1100H Helicopter, Enroute Near Watson Island, Florida - Tail rotor separated following impact with bird. Forced landing resulted in substantial damage to helicopter. Pilot and four passengers escaped injury.

July 3, 1977 - Air Charter Lockheed Electra (U.S. location unknown) - NR 2 engine injested birds and had to be shut down during the approach. Following inspection, NR 3 engine was also damaged requiring two engine changes.

August 5, 1977 - Air Carrier Convair 440, Oernskoeldsvik, Sweden - During descent out of 1,700 feet and at 240 knots, aircraft struck a buzzard, puncturing an 8-inch hole in the wing leading edge outboard of the engine.

August 9, 1977 - Air Carrier B-707, San Francisco, California - Aircraft struck birds on takeoff with the NR 1 engine experiencing a compressor stall. Aircraft returned for landing. NR 1 engine compressor destroyed, requiring engine change; NR 4 engine fan blades also required repair.

August 9, 1977 - Air Taxi Beech 18, Sioux Falls, South Dakota - During a night flight, aircraft hit a bird with impact occurring on the windshield dividing bar, breaking the left windshield. Pilot received minor injuries.

August 30, 1977 - Air Taxi Cessna 170B, Golovin, Alaska - On takeoff climb, aircraft hit a bird which penetrated the engine cowling and struck the ignition system lead wires causing partial power loss. Aircraft was forced to ditch resulting in substantial water damage to aircraft. Pilot and four passengers survived with only minor injuries.

September 12, 1977 - Aerial Spray Callair A-6, Cedar City, Utah - A mourning dove was injested blocking airflow to the engine. Engine failed and aircraft was destroyed in crash. The pilot was seriously injured.

September 15, 1977 - Air Carrier B-737, Honolulu, Hawaii - On approach, a Frigate bird hit first officer's windshield shattering all panes and showering crewmembers with glass. Windshield bowed in but did not fail completely. Captain landed aircraft without further incident.

September 16, 1977 - Lear 24, Baton Rouge, Louisiana - Aircraft aborted a takeoff on a wet runway following an engine injestion and failure. Aircraft left the end of the runway and struck a ditch causing significant aircraft damage. Two crew and six passengers were not injured.

November 3, 1977 - Air Carrier B-747, Newark Airport, New York - Bird strike immediately after takeoff resulted in an engine injestion NR 3 engine. Immediate power loss and engine vibration forced engine shutdown and return for landing. Post-flight inspection revealed that a fan blade had detatched making a 7 x 8-1/2-inch hole in the nose cowl and extensive damage to the compressor section. The bird was a gull.

Attachment 2
(Source: EPA, SW-828, 1980)

Appendix 2(c)-1

AIRPORTS HAVING SOLID WASTE RELATED BIRD HAZARD

AIRPORTS WITH BIRD HAZARDS

ALASKAN REGION

ASSOCIATED CITY	AIRPORT NAME
Kodiak, Alaska	Kodiak State
Homer, Alaska	Homer
Anchorage, Alaska	Merrill Field

NORTHWEST REGION

Renton, Washington	Renton Municipal
Hoquiam, Washington	Bowerman
Bremerton, Washington	Kitsap County

PACIFIC REGION

None

WESTERN REGION

San Francisco, California	San Francisco International
Oakland, California	Metropolitan Oakland
Stockton, California	Stockton Metropolitan
Santa Barbara, California	Santa Barbara Municipal
Concord, California	Buchanan Field

SOUTHWEST REGION

None

GREAT LAKES REGION

Benton Harbor, Michigan	Ross Field
Escanaba, Michigan	Delta County
Lansing, Michigan	Capital City
Duluth, Minnesota	Duluth International
International Falls, Minnesota	Falls International

AIRPORTS WITH BIRD HAZARDS (continued)

SOUTHERN REGION

ASSOCIATED CITY	AIRPORT NAME
Atlanta, Georgia	Hartsfield Atlanta International
Augusta, Georgia	Bush Field

CENTRAL REGION

Omaha, Nebraska	Eppley Airfield

ROCKY MOUNTAIN REGION

Salt Lake City, Utah	Salt Lake City International
Ogden, Utah	Ogden Municipal

NEW ENGLAND REGION

None

EASTERN REGION

Newark, New Jersey	Newark International
Trenton, New Jersey	Mercer County
Atlantic City, New Jersey	Atlantic City Municipal
Atlantic City, New Jersey	NAFEC/Atlantic City
New York, New York	John F. Kennedy International
New York, New York	La Guardia

- Disposal facilities may not necessarily be within the specified distances of these airports
- Listing subject to updating by FAA

Attachment 3
(Source: FAA, 1974)

ORDER DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

5200. 5

10/16/74

SUBJ: FAA GUIDANCE CONCERNING SANITARY LANDFILLS ON OR NEAR AIRPORTS

1. PURPOSE. This order provides guidance concerning the elimination or monitoring of open dumps, waste disposal sites, and sanitary landfills on or in the vicinity of airports.

2. DISTRIBUTION. This order is distributed to Washington headquarters and Regional Airports, Flight Standards and Air Traffic offices to division level; all Airports District Offices; and Flight Standards and Air Traffic field facilities.

3. BACKGROUND. Garbage dumps, sanitary landfills or whatever title is used for this type of operation attract rodents and birds, erodes the airport environment, and where the dump is ignited, creates smoke - all which are undesirable and are potential hazards to aviation.

While the chance of an unforeseeable, random bird strike in flight will always exist, it is nevertheless possible to define the high-risk conditions within fairly narrow limits. Those high-risk conditions exist in the take-off, climb-out, approach and landing areas on and in the vicinity of airports. The increasing number of bird strikes reported on aircraft has become a matter of concern to the FAA and to airport management. Various studies and observations have resulted in the conclusion that sanitary landfills are artificial attractants to birds. Accordingly, landfills located in the vicinity of an airport may incompatible with safe flight operations. Those conditions that are not compatible must be eliminated, to the extent practicable. Airport owners need guidance in making this decision, and the FAA must be in a position to assist. Some airports are not under the jurisdiction of the community or local governing body having control of land usage in the vicinity of the airport. In these cases, the airport owner should use its influence and best efforts to close or control landfill operations within the general vicinity of the airport.

4. ACTION.

   a. Sanitary landfills located within the areas established for an airport by these guidelines as set forth in paragraph 5 of this order should be closed. If a sanitary landfill is determined as

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Distribution: WRAS/AT/FS-2; FFS-0, FAT-0,
FAS-1 (Normal)

Initiated By: AAS-660

incompatible land use under guidelines of paragraph 5 and cannot be closed within a reasonable time, it should be designed and operated in accordance with the criteria and instructions issued by the Environmental Protection Agency, the Department of Health, Education and Welfare, and other such regulatory bodies that may have applicable requirements. FAA should advise airport owners against locating, permitting or concurring in the location of a landfill on or in the vicinity of airports.

b. The operation of a sanitary landfill located beyond the areas described in paragraph 5 and designed in accordance with the guidelines identified in the foregoing paragraph must be properly supervised to insure compatibility with the airport. If at any time the landfill, by virtue of its operation, presents a potential hazard to aircraft operations, the owner shall take action to correct the situation or terminate operation of the landfill. Failure to take corrective action could place the airport owner in noncompliance with the commitments under a grant agreement.

c. An inspection of current operations at existing landfill sites which have a reported potential bird hazard problem will periodically be made and evaluated. A Bird Hazard Group formed under Order 5200.4 dated 11/20/73 could appropriately be available for consultation regarding this activity. Should it be found that birds attracted to the landfill site do in fact constitute a potential hazard to aircraft, the condition will be reported to AAT-430, National Flight Data Center (NFDC), for possible inclusion in the Airman's Information Manual. The appropriate FAA office should immediately evaluate the situation to determine compliance with the grant agreement and take such action as may be warranted under the guidelines as prescribed in Order 5190.6, Airports Compliance Requirements.

d. This order does not apply to landfills used exclusively for the disposal of rock and earth.

e. This order is not intended to resolve all related problems, but is specifically directed toward eliminating sanitary landfills in the proximity of airports, thus providing a safer environment for aircraft operations.

f. The airport operations manual should require landfill site inspections at least semimonthly for those landfill operations that cannot be closed to assure that bird population is not increasing.

g. Additional information on solid waste disposal, bird hazard and related problems may be obtained from the following agencies:

Bureau of Sport Fisheries and Wildlife
U.S. Department of the Interior
18th and C Streets, N.W.
Washington, D.C. 20240

Office of Solid Waste Management
Programs (HM-562)
U.S. Environmental Protection Agency
1835 K Street, N.W.
Washington, D.C. 20406

U.S. Department of Health, Education & Welfare
330 Independence Avenue, S.W.
Washington, D.C. 20201

5. CRITERIA. Sanitary landfills will be considered as an incompatible use if located within areas established for the airport through the application of the following criteria:

a. Landfills located within 10,000 feet of any runway used or planned to be used by turbojet aircraft.

b. Landfills located within 5,000 feet of any runway used only by piston type aircraft.

c. Landfills outside of the above perimeters but within the conical surfaces described by FAR Part 77 and applied to an airport will be reviewed on a case-by-case basis.

d. Any landfill located such that it places the runways and/or approach and departure patterns of an airport between bird feeding, water, or roosting areas.

William V. Vitale
WILLIAM V. VITALE, Acting Director
Airports Service, AAS-1

Attachment 4
(Source: FAA, 1978)

IMPACT ALTITUDE STATISTICS

SOURCE	HEIGHT	REFERENCE
KLM Royal Dutch Airlines 1963-1967	43% at ground level 87% up to 1000' 93% up to 5,500'	(1)
UK Civil Aviation 1966-1971	86% up to 200' 97% up to 2,500'	(2)
USSR Civil Aviation 1966-1971	42% up to 30' 90% up to 1,900'	(3)
CAF 1969-1971	79% up to 1,000' 97% up to 3,000'	(4)
GAF 1966-1968	61% up to 600' 98% up to 2,500'	(5)
RNethAF 1956-1965	92% up to 1,500'	(6)
RNorAF 1961-1972	71% up to 500' 93% up to 1,500'	(7)
USAF 1970-1972	86% up to 2,000' 93% up to 3,000'	(8)
European Airlines (14 countries) 1972-1975	75% at 0-200' 10% at 201'-800' 7% at 801'-2,500' 0% over 2,500'	(9)
USAF 1975	55% at 0-500' 20% at 501'-1,000' 19% at 1,001'-2,000' 3% at 2,001'-3,000' 3% over 3,000'	(10)

Attachment 5
(Source: DOI, 1978)

APPENDIX A

BIRDS MOST COMMONLY OBSERVED ADJACENT TO THE RUNWAYS AT TOMPKINS COUNTY AIRPORT

SPECIES	JAN.	APR.	JUNE	AUG.	OCT.	DEC.	TOTAL
Pied-billed grebe		x					1
* * Great blue heron				x	x		2
* * Green heron				x			1
Mallard				x	x		2
Black duck	x	x		x	x	x	5
Baldpate					x		1
Blue-winged teal		x					1
Rough-legged hawk	x					x	2
Sparrow hawk		x	x	x	x		4
Coot			x				1
Killdeer		x		x			2
Wilson's snipe		x					1
* * Ring-billed gull		x			x		2
Mourning dove				x			1
Kingfisher				x	x		2
Flicker				(x)			1
Kingbird				x			1
Mixed swallow				x			1
Blue Jay	(x)					(x)	2
* Crow	(x)	x	x	x	x	(x)	6

(Cont'd.)

APPENDIX A (Cont'd.)

	SPECIES	JAN.	APR.	JUNE	AUG.	OCT.	DEC.	TOTAL
	Catbird				(x)			1
	Robin		x		(x)	(x)		3
* *	Starling			x	x	x		3
	Bobolink			(x)				1
	Meadowlark				x			1
* *	Red-wing blackbird		(x)	(x)	x	x		4
	Grackle		x					1
	Goldfinch				(x)			1
	White-throated sparrow					(x)		1
	Song sparrow				x			1
	TOTAL	4	11	6	19	12	4	

* * Species which potentially pose the greatest hazard to jet aircraft.
(x) Species which were most common or numerous at the time of the survey.

Attachment 6
(Source: PEI, 1986)

TABLE 5-2. LOCATION STANDARDS AND RESTRICTIONS

State	Distance from habitable residence	Distance from water table	Distance from property boundary	Distance from airports		Distance from utility lines	Distance from domestic wells	May not pose bird hazard to aircraft	Distance from community water supplies	Distance from surface water	Not to be located in sink-holes, karst terrain or active faults	Not to be located in critical habitat areas	Restricted to certain soil groups	Distance from public road
				Turbo-jet	Piston-type									
Alabama		5'		10,000'	5,000'			x			x	x		
Alaska[d]			50'					x						
Alaska			50'					x						
Arizona														
Arkansas		"Safe"											x	
California		5'									x (faults)			
Colorado		x		10,000'	5,000'			x	x					
Connecticut		60"							1000'			x		
Delaware		3'								100'				
Dist. of Col.[a]														
Florida				10,000'	5,000'		500'			3000'	x (by site)			
Georgia														
Hawaii														
Idaho														
Illinois														
Indiana	600'	x												
Iowa	500'	5'	20'	x			1000'		1 mi					
Kansas				x		25'						x		
Kentucky	250'		100'							200'		x		100'
Louisiana			200'	10,000'	5,000'							x		
Maine	1000'	5'	100'	10,000'	5,000'		1000'		1000'	300'		x		
Maryland														
Maryland[d]														
Massachusetts		4'												
Massachusetts[d]	500	5'	100'	x			1000'					x		1000'
Michigan		40'												
Minnesota	1000'		20'							300'/1000'				
Mississippi			<50'	2 mi	1 mi	25'		x	500'					
Missouri														
Montana		10-20'												1000'
Nebraska		x		10,000'	5,000'									
Nevada	1/4, 1/2, 3/4 mi	4'												
New Hampshire									x			x		

(continued)

TABLE 5-2 (continued)

State	Distance from habitable residence	Distance from water table	Distance from property boundary	Distance from airports		Distance from utility lines	Distance from domestic wells	May not pose bird hazard to aircraft	Distance from community water supplies	Distance from surface water	Not to be located in sink-holes, karst terrain or active faults	Not to be located in critical habitat areas	Restricted to soil groups	Distance from public road
				Turbo-jet	Piston-type									
New Jersey			50'	2.5 mi	2.5 mi									
New Mexico			20'											
New York		5'	50'	10,000'	5,000'			x				x	x	
North Carolina	500'	4'	50'	10,000'	5,000'		500'		500'	50'		x		
North Dakota				x										
Ohio		5'							1000'	200'				
Oklahoma	500 y'ds		50'	10,000'	5,000'	25'								
Oregon														
Pennsylvania														
Rhode Island		5'	200'						400'	200'		x		
South Carolina														
South Dakota		6'								1000'		x		
Tennessee	x													
Texas			50'	10,000'	5,000'	25'	x		500'			x		300 yds[b]
Utah		5'												
Vermont		10'[b]								300'/500'[c]	x[c]			
Virginia														
Washington		4'												
West Virginia								x				x		
Wisconsin			100'	10,000'	5,000'		1200'		1200'	300'/1000'				1000'
Wyoming	1000'								500'					
American Samoa														
Guam								x				x		
N. Mariana Is.[d]				10,000'							x	x		
Puerto Rico								x	500'[e]					
Virgin Is.[a]														

[a] Information not received.

[b] Sites serving less than 5000 people.

[c] In guidelines.

[d] Proposed regulations.

[e] May be decreased with Board approval or installation of groundwater monitoring.

Attachment 7
(Source: EPA, SW-828, 1980)

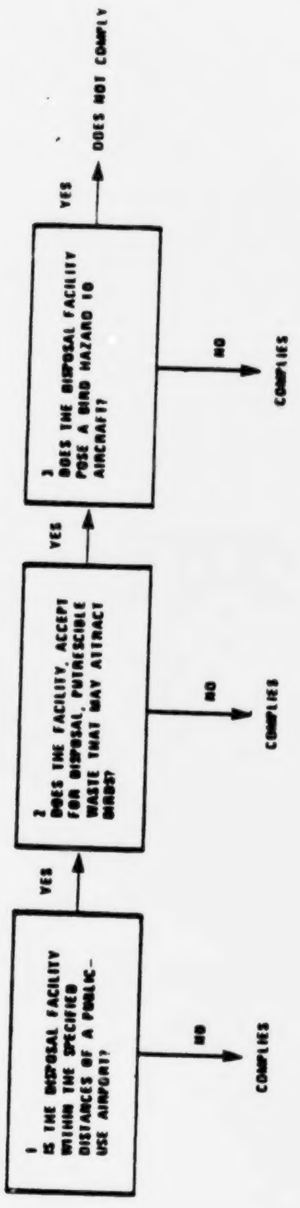
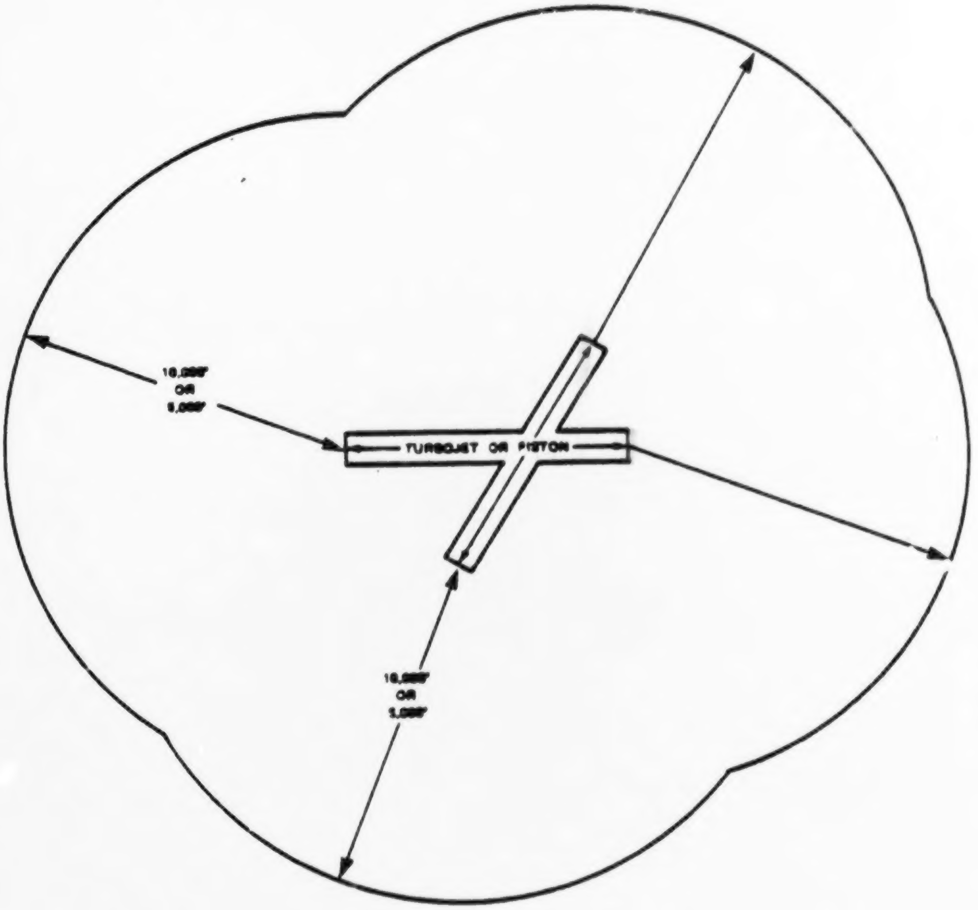

1
IS THE DISPOSAL FACILITY WITHIN THE SPECIFIED DISTANCES OF A PUBLIC-USE AIRPORT?
NO
COMPLIES
YES
2
DOES THE FACILITY, ACCEPT FOR DISPOSAL, PUTRESCIBLE WASTE THAT MAY ATTRACT BIRDS?
NO
COMPLIES
YES
3
DOES THE DISPOSAL FACILITY POSE A BIRD HAZARD TO AIRCRAFT?
NO
COMPLIES
YES
DOES NOT COMPLY

FIGURE 2(c)1 FLOW CHART -SAFETY-BIRD HAZARDS TO AIRCRAFT

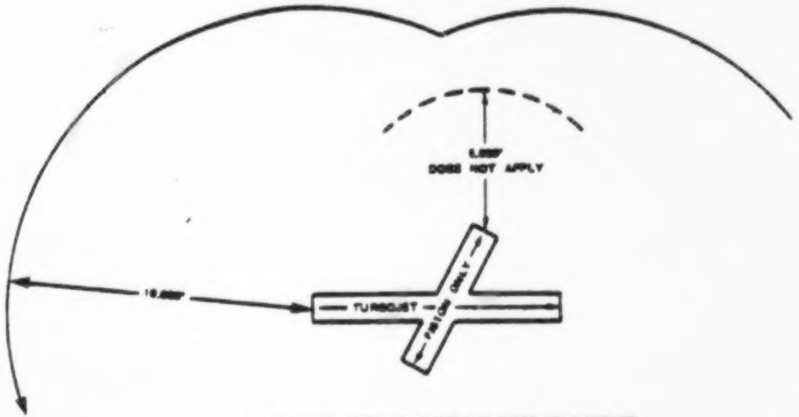
11/79

Attachment 8
(Source: EPA, SW-828, 1980)

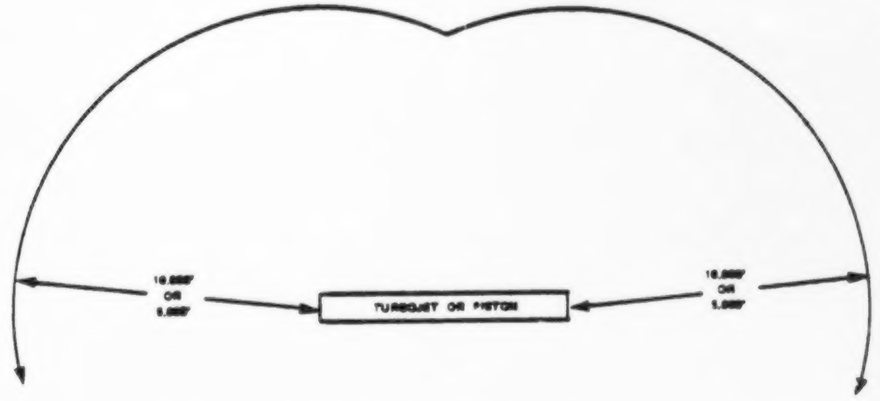

10,000'
OR
5,000'
TURBOJET OR PISTON
10,000'
OR
5,000'

A. BOTH RUNWAYS HANDLING SAME TYPE OF AIRCRAFT

FIGURE 2(c)-3 MEASUREMENT OF DISTANCE FROM RUNWAY


5,000'
DOES NOT APPLY
10,000'
TURBOJET
PISTON ONLY

B. RUNWAYS HANDLING DIFFERENT TYPES OF AIRCRAFT


10,000'
OR
5,000'
TURBOJET OR PISTON
10,000'
OR
5,000'

C. SINGLE RUNWAY, EITHER TYPE OF AIRCRAFT

FIGURE 31a1-3 (CONTINUED) MEASUREMENT OF DISTANCE FROM RUNWAY

Attachment 9
(Source: EPA, SW-828, 1980)

Appendix 2(c)-2

AIRPORTS HAVING A KNOWN BIRD HAZARD

AIRPORTS WITH BIRD HAZARDS

ALASKAN REGION

ASSOCIATED CITY	AIRPORT NAME

None

NORTHWEST REGION

Seattle, Washington	Boeing Field/King County
Moses Lake, Washington	Grant County
Lewiston, Idaho	Lewiston-Nez Perce County
Pocatello, Idaho	Pocatello Municipal
Salem, Oregon	McNary Field
Medford, Oregon	Medford-Jackson County
Astoria, Oregon	Clatsop County
Idaho Falls, Idaho	Fanning Field

PACIFIC REGION

Pago Pago, Samoa	Pago Pago International
Honolulu, Hawaii	Honolulu International
Kahului, Hawaii	Kahului, International
Lihue, Hawaii	Lihue International
Lanai City, Hawaii	Lanai

WESTERN REGION

Los Angeles, California	Los Angeles International
Sacramento, California	Sacramento Metropolitan
Sacramento, California	Sacramento Executive
Santa Ana, California	John Wayne/Orange County
Napa, California	Napa County
San Diego, California	San Diego International
Fresno, California	Fresno Air Terminal
Burbank, California	Hollywood Burbank
Santa Monica, California	Santa Monica Municipal
Livermore, California	Livermore
Palo Alto,California	Palo Alto

AIRPORTS WITH BIRD HAZARDS (continued)

ASSOCIATED CITY	AIRPORT NAME
WESTERN REGION (continued)	
Long Beach, California	Long Beach/Daugherty Field
Santa Maria, California	Santa Maria Public
Torrance, California	Torrance Municipal
Compton, California	Compton Airport
Phoenix, Arizona	Phoenix-Sky Harbor
Reno, Nevada	Reno International
SOUTHWEST REGION	
Tulsa, Oklahoma	Tulsa International
Lawton, Oklahoma	Lawton Municipal
New Orleans, Louisiana	Lakefront International
New Orleans, Louisiana	New Orleans International
Monroe, Louisiana	Monroe Regional
GREAT LAKES REGION	
South Bend, Indiana	Michiana Regional
Detroit, Michigan	Detroit City
Detroit, Michigan	Detroit Metropolitan
Detroit, Michigan	Willow Run
Grand Rapids, Michigan	Kent County International
Kalamazoo, Michigan	Kalamazoo Municipal
Muskegon, Michigan	Muskegon County
Chicago, Illinois	Merrill C. Meigs
Chicago, Illinois	Chicago Midway
Moline, Illinois	Quad City
Alexandria, Minnesota	Chandler Field
St. Paul, Minnesota	Holman Field
Appleton, Wisconsin	Outagamie County
Green Bay, Wisconsin	Austin-Straubel Field
La Crosse, Wisconsin	La Crosse Municipal
Manitowoc, Wisconsin	Manitowoc County
Milwaukee, Wisconsin	General Mitchell Field
Oshkosh, Wisconsin	Wittman Field

AIRPORTS WITH BIRD HAZARDS (continued)

ASSOCIATED CITY	AIRPORT NAME
SOUTHERN REGION	
Tampa, Florida	Tampa International
Sarasota/Bradenton, Florida	Sarasota-Bradenton
Ft. Myers, Florida	Page Field
Miami, Florida	Miami International
Orlando, Florida	Orlando International
St. Petersburg/Clearwater, Florida	St. Petersburg/Clearwater Int'l
Melbourne, Florida	Melbourne Regional
Marathon, Florida	Marathon Flight Strip
Jacksonville, Florida	Jacksonville International
Key West, Florida	Key West International
Lake Okeechobee	Lake Okeechobee Municipal
Brunswick, Georgia	Glynco Jetport
Birmingham, Alabama	Birmingham Municipal
Muscle Shoals, Alabama	Muscle Shoals
Anniston, Alabama	Anniston - Calhoun County
Louisville, Kentucky	Standford Field
Lexington, Kentucky	Blue Grass
Wilmington, North Carolina	New Hanover County
Memphis, Tennessee	Memphis International
Nashville, Tennessee	Nashville Metropolitan
Christiansted, Virgin Islands	Alexander Hamilton
San Juan, Puerto Rico	Puerto Rico International
CENTRAL REGION	
Wichita, Kansas	Wichita Mid-Continent
Sioux City, Iowa	Mason City Municipal
Columbia, Missouri	Columbia Regional
St. Louis, Missouri	Lambert-St. Louis International
Kaiser, Missouri	Lee C. Fine Memorial
Cape Girardeau, Missouri	Cape Girardeau Municipal

AIRPORTS WITH BIRD HAZARDS (continued)

ASSOCIATED CITY	AIRPORT NAME
ROCKY MOUNTAIN REGION	
Bismarck, North Dakota	Bismarck Municipal
Watertown, South Dakota	Watertown Municipal
Helena, Montana	Helena
Cody, Wyoming	Cody Municipal
NEW ENGLAND REGION	
Willimantic, Connecticut	Willimantic - Windom
New Haven, Connecticut	Tweed - New Haven
Boston, Massachusetts	General Edward Lawrence Logan
Hyannis, Massachusetts	Barnstable Municipal
EASTERN REGION	
Buffalo, New York	Greater Buffalo International
Ithaca, New York	Tompkins County
Islip, New York	Islip McArthur
Teterboro, New Jersey	Teterboro
Farmingdale, New York	Republic Airport
Poughkeepsie, New York	Dutchess County
Harrisburg, Pennsylvania	Capital City

- Disposal facilities may not necessarily be within the specified distances of these airports
- Listing subject to updating by FAA

Attachment 10

EXECUTIVE ORDER 11988
Floodplain Management

(May 24, 1977; Amended by Executive Order 12148 of July 20, 1979 — Federal Emergency Management, 44 FR 43239, July 24, 1979)

(*Editor's note:* Executive Order 12148 — Federal Emergency Management, July 20, 1979, substituted "Director of the Federal Emergency Management Agency" for "Federal Insurance Administration" in Section 2(d).)

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 *et seq.*), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Stat. 975), in order to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative, it is hereby ordered as follows:

Section 1. Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Sec. 2. In carrying out the activities described in Section 1 of this Order, each agency has a responsibility to evaluate the potential effects of any actions it may take in a floodplain; to ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management; and to prescribe procedures to implement the policies and requirements of this Order, as follows:

(a)(1) Before taking an action, each agency shall determine whether the proposed [illegible] will occur in a floodplain — for major Federal actions significantly affecting the quality of the human environment, the evaluation required below will be included in any statement prepared under Section 102(2)(C) of the National Environmental Policy Act. This determination shall be made according to a Department of Housing and Urban Development (HUD) floodplain map or a more detailed map of an area, if available. If such maps are not available, the agency shall make a determination of the location of the floodplain based on the best available information. The Water Resources Council shall issue guidance on this information not later than October 1, 1977.

(2) If an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a floodplain, the agency shall consider alternatives to avoid adverse effects and incompatible development in the floodplains. If the head of the agency finds that the only practicable alternative consistent with the law and with the policy set forth in this Order requires siting in a floodplain, the agency shall, prior to taking action, (i) design or modify its action in order to minimize potential harm to or within the floodplain, consistent with regulations issued in accord with Section 2(d) of this Order, and (ii) prepare and circulate a notice containing an explanation of why the action is proposed to be located in the floodplain.

(3) For programs subject to the Office of Management and Budget Circular A-95, the agency shall send the notice, not to exceed three pages in length including a location map, to the state and areawide A-95 clearinghouses for the geographic areas affected. The notice shall include: (i) the reasons why the action is proposed to be located in a floodplain; (ii) a statement indicating whether the action conforms to applicable state or local floodplain protection standards and (iii) a list of the alternatives considered. Agencies shall endeavor to allow a brief comment period prior to taking any action.

(4) Each agency shall also provide opportunity for early public review of any plans or proposals for actions in floodplains, in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended.

Attachment 10
(Cont.)

(b) Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in a floodplain, whether the proposed action is in accord with this Order.

(c) Each agency shall take floodplain management into account when formulating or evaluating any water and land use plans and shall require land and water resources use appropriate to the degree of hazard involved. Agencies shall include adequate provision for the evaluation and consideration of flood hazards in the regulations and operating procedures for the licenses, permits, loan or grants-in-aid programs that they administer. Agencies shall also encourage and provide appropriate guidance to applicants to evaluate the effects of their proposals in floodplains prior to submitting applications for Federal licenses, permits, loans or grants.

(d) As allowed by law, each agency shall issue or amend existing regulations and procedures within one year to comply with this Order. These procedures shall incorporate the Unified National Program for Floodplain Management of the Water Resources Council, and shall explain the means that the agency will employ to pursue the nonhazardous use of riverine, coastal and other floodplains in connection with the activities under its authority. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order. Agencies shall prepare their procedures in consultation with the Water Resources Council, the Director of the Federal Emergency Management Agency, and the Council on Environmental Quality, and shall update such procedures as necessary.

Sec. 3. In addition to the requirements of Section 2, agencies with responsibilities for Federal real property and facilities shall take the following measures:

(a) The regulations and procedures established under Section 2(d) of this Order shall, at a minimum, require the construction of Federal structures and facilities to be in accordance with the standards and criteria and to be consistent with the intent of those promulgated under the National Flood Insurance Program. They shall deviate only to the extent that the standards of the Flood Insurance Program are demonstrably inappropriate for a given type of structure or facility.

(b) If, after compliance with the requirements of this Order, new construction of structures or facilities are to be located in a floodplain, accepted floodproofing and other flood protection measures shall be applied to new construction or rehabilitation. To achieve flood protection, agencies shall, wherever practicable, elevate structures above the base flood level rather than filling in land.

(c) If property used by the general public has suffered flood damage or is located in an identified flood hazard area, the responsible agency shall provide on structures, and other places where appropriate, conspicuous delineation of past and probable flood height in order to enhance public awareness of and knowledge about flood hazards.

(d) When property in floodplains is proposed for lease, easement, right-of-way, or disposal to non-Federal public or private parties, the Federal agency shall (1) reference in the conveyance those uses that are restricted under identified Federal, State or local floodplain regulations; and (2) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successors, except where prohibited by law; or (3) withhold such properties from conveyance.

Sec. 4. In addition to any responsibilities under this Order and Sections 202 and 205 of the Flood Disaster Protection Act of 1973, as amended (42 U.S.C. 4106 and 4128), agencies which guarantee, approve, regulate, or insure any financial transaction which is related to an area located in a floodplain shall, prior to completing action on such transaction, inform any private parties participating in the transaction of the hazards of locating structures in the floodplain.

Sec. 5. The head of each agency shall submit a report to the Council on Environmental Quality and to the Water Resources Council on June 30, 1978, regarding the status of their procedures and the impact of this Order on the agency's operations. Thereafter, the Water Resources Council shall periodically evaluate agency procedures and their effectiveness.

Sec. 6. As used in this Order:

(a) The term "agency" shall have the same meaning as the term "Executive agency" in Section 105 of Title 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in Section 1 which are located in or affecting floodplains.

(b) The term "base flood" shall mean that flood which has a one percent or greater chance of occurrence in any given year.

(c) The term "floodplain" shall mean the lowland and relatively flat areas adjoining inland and coastal waters including floodprone areas of offshore islands, including at a minimum, that area subject to a one percent or greater chance of flooding in any given year.

Sec. 7. Executive Order No. 11296 of August 10, 1966, is hereby revoked. All actions, procedures, and issuances taken under that Order and still in effect shall remain in effect until modified by appropriate authority under the terms of this Order.

Sec. 8. Nothing in this Order shall apply to assistance provided for emergency work essential to save lives and protect property and public health and safety, performed pursuant to Sections 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

Sec. 9. To the extent the provisions of Section 2(a) of this Order are applicable to projects covered by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decisionmaking, and action pursuant to the National Environmental Policy Act of 1969, as amended.

/s/JIMMY CARTER

THE WHITE HOUSE,
May 24, 1977

Attachment 11
(Source: GCA, 1986a)

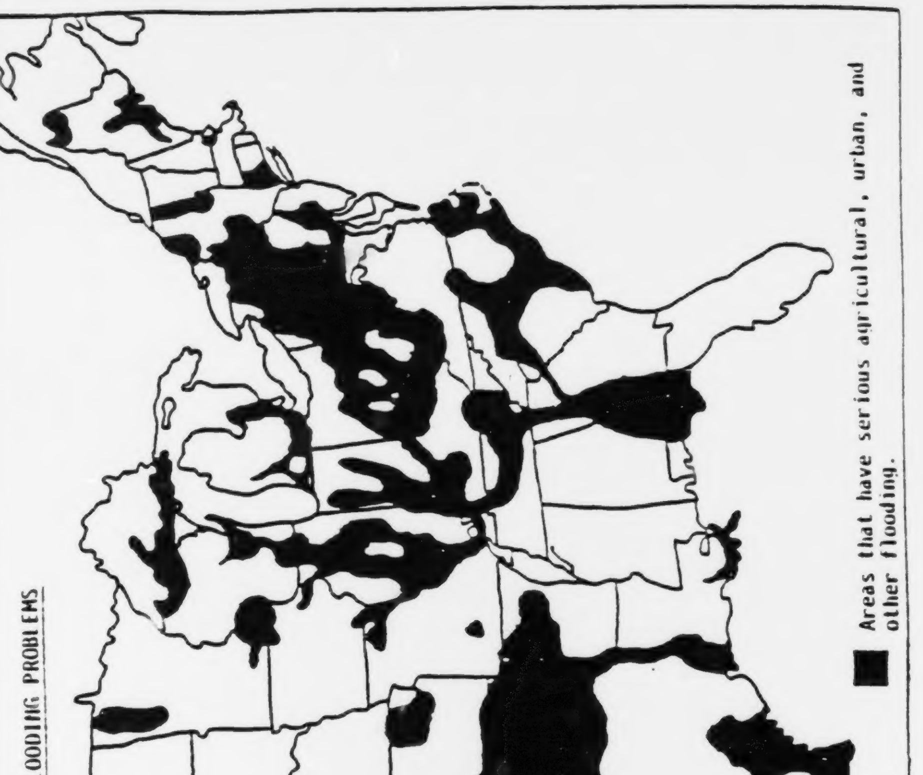
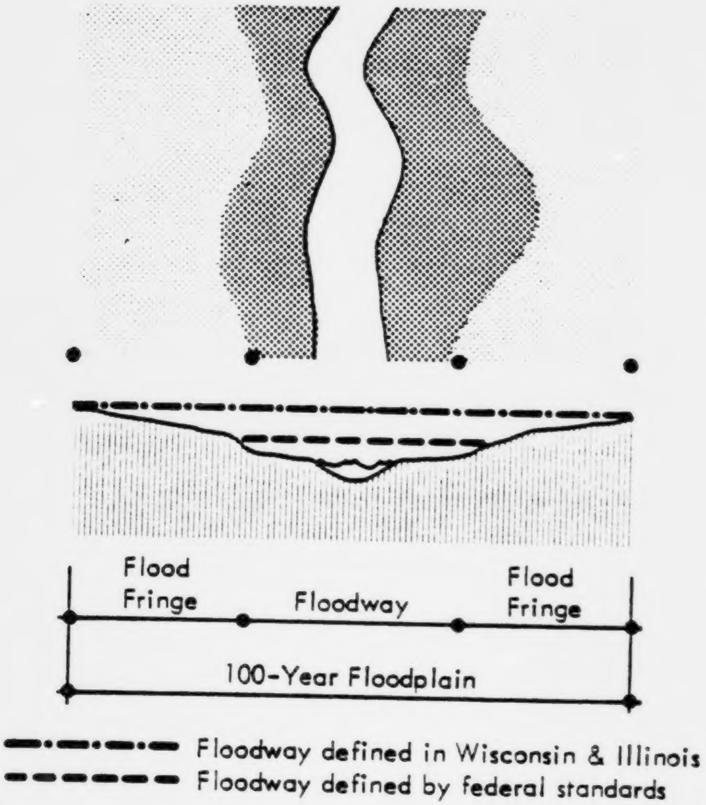

EXISTING FLOODING PROBLEMS
Areas that have serious agricultural, urban, and other flooding.

Figure 2-2. Existing flooding problems in the United States (Water Resources Council, 1978).

Attachment 12
(Source: MRI, 1984)


Flood Fringe
Floodway
Flood Fringe
100-Year Floodplain
Floodway defined in Wisconsin & Illinois
Floodway defined by federal standards

Source: Federal Emergency Management Agency. Design Guidelines for Flood Damage Reduction. Prepared by AIA Research Corporation, Publication No. FEMA-15, U.S. Government Printing Office, Washington, D.C., December, 1981

Figure 1. The regulatory riverine floodplain.

Attachment 13
(Source: MRI, 1984)

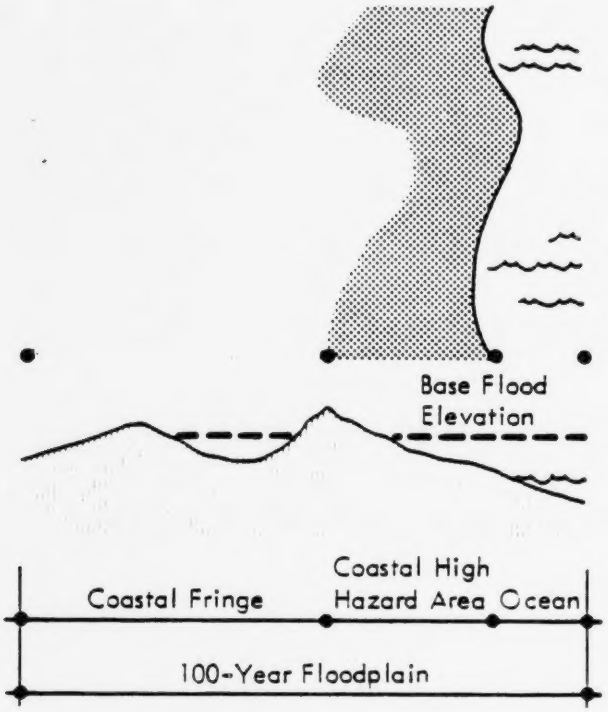

Base Flood
Elevation
Coastal Fringe
Coastal High
Hazard Area
Ocean
100-Year Floodplain

Figure 2. The regulatory coastal floodplain.

Attachment 14
(Source: PEI, 1986)

TABLE 5-1. FLOOD PLAIN PROTECTION

State	Prohibited in 100-year floodplain	Restricted in 100-year floodplain				Avoid sites subject to flooding
		Physical barrier[e]	May not restrict flow of flood	May not decrease temporary water storage capacity	May not cause washout of solid waste	
Alabama			x	x	x	
Alaska			x	x	x	
Alaska[c]		x[d]	x	x	x	
Arizona						
Arkansas						x
California		x			x	
Colorado	x					
Connecticut			x	x	x	
Delaware						
Dist. of Col.[a]						
Florida						x
Georgia						
Hawaii		x				
Idaho						
Illinois						
Indiana		x				
Iowa		x				
Kansas		x		x		
Kentucky		x	x	x	x	
Louisiana		x				
Maine	x					
Maryland						
Maryland[c]						
Massachusetts						
Massachusetts[c]	x					
Michigan		x				
Minnesota	x					
Mississippi		x		x	x	
Missouri		x				
Montana	x					
Nebraska						x
Nevada						
New Hampshire		x	x	x	x	

(continued)

TABLE 5-1 (continued)

State	Prohibited in 100-year floodplain	Restricted in 100-year floodplain				Avoid sites subject to flooding
		Physical barrier[e]	May not restrict flow of flood	May not decrease temporary water storage capacity	May not cause washout of solid waste	
New Jersey						
New Mexico						
New York						
North Carolina		x	x	x	x	
North Dakota						
Ohio	x					
Oklahoma	x					
Oregon			x	x	x	
Pennsylvania	x					
Rhode Island			x	x	x	
South Carolina						
South Dakota		x				
Tennessee	x					
Texas		x				
Utah						
Vermont	x[b]					
Virginia						
Washington						
West Virginia		x	x	x	x	
Wisconsin	x					
Wyoming						
Am Samoa						
Guam			x	x	x	
N. Mariana Is.[c]						x
Puerto Rico[d]			x	x	x	
Virgin Is.[a]						

[a] Information not received.

[b] In guidelines.

[c] Proposed regulations.

[d] At Department's discretion.

[e] Dikes, berms, levees or other means to prevent water from contacting waste.

Attachment 15
(Source: MRI, 1984)

TABLE 1. FEDERAL, STATE, AND LOCAL SOURCES OF INFORMATION ON FLOODING AND FLOODPLAIN MANAGEMENT

	DATA TYPE												
AGENCY	Coastal Surveys & Reports	Flood Control Measure	Flood Hazard Reports	Flood Insurance Studies	Floodplain Information Reports	Flood Records & Probabilities	Floodplain Technical Studies	Hydrologic Atlases	National Flood Insurance Program Regulations	State Floodplain Regulations	Technical Assistance	Topographic Maps	Zoning Ordinances & Maps
Local Government Planning Agency or Municipal Engineer			●	●			●		●	●			●
State Floodplain Management Coordinating Agency			●	●			●		●	●	●		
State Office of Coastal Zone Management	●						●			●			
Federal Emergency Management Agency			●	●					●		●		
National Oceanic and Atmospheric Administration (Department of Commerce)	●		●	●		●							
Soil Conservation Service (U.S. Dept. of Agriculture)		●	●	●		●							
U.S. Army Corps of Engineers (Department of Defense)		●	●	●	●	●					●		
U.S. Geological Survey (Department of the Interior)			●	●		●	●	●				●	
Regional Authorities (e.g., TVA)		●	●	●		●	●				●	●	

Attachment 16
(Source: EPA, SW-828, 1980)

TABLE 8-1

FLOOD HAZARD RANKING

Floodplain Characteristics	Increasing Flood Hazard Potential →	
	Low	High
(1) Location in the floodplain	flood fringe	floodway
(2) Size of watershed	small	large
(3) Shape of the floodplain	broad, shallow	narrow, v-shaped
(4) Percentage of the floodplain cross-section area occupied by the facility	small percent	large percent
(5) Volume of facility (acreage and depth)	small	large
(6) Flood flow velocity	low velocity	high velocity

Attachment 17

MEMORANDUM OF AGREEMENT BETWEEN THE ENVIRONMENTAL PROTECTION AGENCY AND THE DEPARTMENT OF THE ARMY

1. Authority: Section 404(q) of the Clean Water Act, 33 U.S.C. §1344(q).

2. Purpose: The purpose of this agreement is to establish policies and procedures to implement Section 404(q) of the Clean Water Act to "minimize, to the maximum extent practicable, duplication, needless paperwork and delays in the issuance of permits."

3. Applicability: This agreement shall apply to applications for permits to be issued by the Department of the Army under:

   a. Section 10 of the River and Harbor Act of 1899.

   b. Section 404 of the Clean Water Act.

   c. Section 103 of the Marine Protection, Research and Sanctuaries Act, except as pertains to compliance with the Environmental Protection Agency (EPA) established ocean dumping criteria.

4. General Rules: Policy and procedures for review of permit applications are established in 33 CFR 320 through 330, and 40 CFR 230.

5. Policy for Interagency Coordination:

   a. The final permit decision will be made by the District Engineer (DE) in the vast majority of cases, and the need for reopening the record of a case developed by the DE will be minimized.

   b. The Administrator has designated the Assistant Administrator, Office of External Affairs (AAEA), as the EPA official having authority to request that the Army review a DE's decision to issue a permit under Section 404. It is agreed that EPA will request such review only if the AAEA finds the following instances:

      (1) That there has been insufficient interagency coordination at the District and Division levels including a procedural failure to coordinate or a failure to resolve stated EPA concerns regarding compliance with the Section 404(b)(1) Guidelines; or

      (2) That significant new information has been developed which was not previously available; or

      (3) That the project raises environmental issues of national importance requiring policy level review.

In all these instances, the AAEA will state how the matters of concern are clearly within the Agency's authority.

c. For projects of other Federal agencies, Army and EPA will accept, where appropriate and legally permissible, the environmental documentation and decisions of those agencies.

d. This agreement does not diminish either Army's authority to decide whether a particular permit application should be granted, including determining whether the project is in compliance with the Section 404(b)(1) Guidelines, or the Administrator's authority under Section 404(c) of the Clean Water Act.

6. Procedures at the initial decision-making levels:

a. In order to be eligible for referral under the procedures provided for under paragraph 7, EPA comment letters including recommended permit denial letters, letters recommending project modification, or requests for extensions of the comment period, shall be signed by the Regional Administrator (RA) or his specified designee (such designee will not be below the level of Division Director; two officials will be designated in Region X to provide for special circumstances in Alaska). Where the RA has delegated such signature authority to a regional official, the RA shall provide in writing, to each Division and District Engineer in his Region, the title of the designated official.

b. The DE will take reasonable steps to ensure that public notices are promptly transmitted to the appropriate EPA office. EPA will submit its comments, if any, during the basic comment period specified in the public notice. Where the basic comment period is less than 30 calendar days, the DE shall upon request of the EPA extend the comment period to 30 calendar days. Otherwise, extensions of the basic or extended comment period will not exceed 30 calendar days and will be authorized only upon written request to the DE from the EPA. The request must be received during the period sought to be extended and must demonstrate the reason for the extension. The DE will respond to the request in writing within five calendar days of the letter of request. Transmittal provisions of subparagraph 7.e. will apply to this response.

c. The agencies will develop techniques at the field level to ensure that formal referral procedures are started only when warranted. These techniques will include an informal consultation procedure initiated by the DE after the close of the comment period to alert the RA (or designee) of an upcoming decision which will be contrary to a recommendation by EPA for permit denial or project modification. The consultation will consist of such actions as telephone calls, electronic mail messages, visits, or other informal techniques. It should include a discussion of the anticipated decision and of the rationale leading to that decision. It is incumbent on EPA to ensure that any additional views regarding the action are finalized and communicated to the DE as expeditiously as possible. In specific cases, the DE and RA (or designee) may determine that the informal consultation should include the applicant. If the applicant is not included, and the consultation results in any substantive action on the application, the DE will inform the applicant of the substance of the consultation and will provide the opportunity for the applicant to comment. Such consultation will occur immediately after the close of the comment period and prior to the DE's Notice of Intent to Issue a permit. This consultation will not affect the time requirements specified in other parts of this MOA or in 33 CFR 320-330.

d. If at the conclusion of the consultation identified at 6.c. above, the DE subsequently finds the proposed permit is in the public interest and complies with the Section 404(b)(1) Guidelines, and intends to issue the permit over EPA objections or to issue it without conditions specified by EPA, he will so notify EPA. When requested by the RA within 7 calender days of such notification, the DE will not issue a Notice of Intent letter until after the RA has had the opportunity to discuss the application with the appropriate Division Engineer during the regular meetings identified at subparagraph 6.e. If no regular meeting has been scheduled within 14 calendar days of the RA's request to delay the Notice of Intent letter and no special meeting or conference call occurs where there has been a reasonable opportunity for discussion within such 14 days, the DE may proceed to issue his Notice of Intent letter pursuant to subparagraph 7.c.

e. Frequent and regular meetings (it is suggested they be monthly, but sooner if appropriate to expedite the permit process) will be scheduled between the RA and Division Engineer by mutual agreement, to discuss issues of mutual interest including problems involving individual permit decisions or patterns of concern such as consistently inappropriate comment letters or regular misinterpretation of the Section 404(b)(1) Guidelines, to ensure proper coordination on enforcement matters, to review the nature and frequency of letters of intent to elevate, and to monitor program implementation to minimize duplication and red tape. This consultation is intended to reduce potential delays in the permit process by raising major issues to the RA/Division Engineer level during the permit process, thereby shortening or eliminating the time required for additional consultation and review.

f. The agencies agree to cooperate fully in the transfer of all information necessary for the agencies to carry out their respective responsibilities. In special cases involving copying of voluminous documentation the parties shall make mutually agreeable arrangements to ensure prompt and effective transfer of required information.

g. Both parties will take the internal measures necessary to assure that the letter and spirit of this agreement are understood at all levels within their agency.

7. Procedures for Referral:

a. General: In the vast majority of cases, the entire process of consultation and referral outlined in this paragraph, when activated, should be completed within 90 calendar days of the DE's Notice of Intent to Issue a permit; in no cases should the process exceed 120 calendar days.

b. If during the comment period EPA recommends that a proposed permit be denied or that the activity be modified as a condition of the permit and the matter has not been resolved under the consultation process provided at subparagraphs 6.c. through 6.e. above, the DE will so notify the RA by letter (Notice of Intent to Issue) and will defer final action pending completion of the procedures in subparagraphs 7.c. and 7.d. The DE's letter to the RA will include a brief summary of how EPA's comments were considered, together with a copy of the DE's findings in support of the decision.

c. Within 20 working days of the DE's Notice of Intent to Issue, if the case has not been resolved to the satisfaction of the AAEA and he determines that it meets the criteria in paragraph 5.b., the AAEA may request of the Assistant Secretary of the Army (Civil Works) (ASA(CW)) that the permit decision be made at a higher level in the Department of the Army. This request will be written, cite the issues invoved as stated at subparagraph 5.b., and describe:

   1) the affected natural resource;

   2) the impacts of the applicant's proposed project on such resources; and

   3) where the request is based on insufficient interagency coordination, the coordination problem, including when applicable, a discussion of why he believes the DE's response is inadequate with respect to project compliance with the Section 404(b)(1) Guidelines.

d. Within 15 working days of the date of the letter of the AAEA, the ASA(CW) will decide whether or not the permit decision will be made at a level higher than the DE and, if so, at what level the final decision will be made. He will notify in writing the agency officials involved. Should the ASA(CW) decide that the permit decision will not be made at a higher level, he will respond to the AAEA in writing presenting the results of his evaluation which will include a discussion of the following:

   1) the issues raised by the AAEA under subparagraph 7.c.;

   2) his position on these issues and supporting bases; and

   3) any administrative action taken by the ASA(CW) to improve program implementation which resulted from the AAEA request.

e. Each agency will ensure that all letters to the other agency required by this paragraph will be received within one day of signature using messenger, electronic transmittal or other appropriate means.

f. EPA and the Department of the Army desire to avoid the use of duplicative review mechanisms. A permit decision will not be subject to the referral process when the Department of the Army and EPA agree in advance that an adequate separate review mechanism exists and has been invoked.

8. For any permit where EPA has invoked the referral procedures of paragraph 7 and where at the end of such procedures Army intends to issue the permit in a form that does not meet all of EPA's objections, the ASA(CW) will so notify the AAEA in writing. This letter will include the discussion required in subparagraph 7.d. To assist the EPA in reaching a decision on whether to exercise its Section 404(c) authority, the ASA(CW) will also provide a copy of the Statement of Findings/Record of Decision prepared in support of the permit decision. The permit shall not be issued during a period of 10 working days after such notice unless it contains a condition that no activity may take place pursuant to the permit until such 10th day or, if EPA has initiated a Section 404(c) proceeding during such 10 day period, until the Section 404(c) proceeding is concluded and subject to the final determination in such proceeding.

9. This agreement is effective immediately upon the last signature date below and will continue in effect until modified or revoked by agreement of both parties, or revoked by either party alone upon six months written notice.

10. The Memorandum of Agreement between the Administrator of EPA and the Secretary of the Army on permit processing dated July 7, 1982 is terminated. Those permit applications which have already been referred to the ASA(CW) under the July 7, 1982 MOA shall be processed according to its terms. Those permit applications for which Notices of Intent to Issue have been sent by the DE since 20 days prior to the effective date of this MOA, but which have not yet been referred to the ASA(CW) shall be governed by this agreement, except that the time periods specified in subparagraphs 7.c. and 7.d. shall run from the date of this agreement rather than from the date of the DE's letter.

Lee M. Thomas
Administrator of the
Environmental Protection Agency

Nov. 6, 1985
Date

John O. Marsh, Jr.
Secretary of the Army

12 Nov. '85
Date

Attachment 18

EXECUTIVE ORDER 11990

Protection of Wetlands

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative, it is hereby ordered as follows:

Section 1. (a) Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

(b) This Order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property.

Sec. 2. (1) In furtherance of Section 101 (b) (3) of the National Environmental Policy Act of 1969 (42 U.S.C. 4331 (b) (3)) to improve and coordinate Federal plans, functions, programs and resources to the end that the Nation may attain the widest range of beneficial uses of the environment without degradation and risk to health or safety, each agency, to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use. In making this finding the head of the agency may take into account economic, environmental and other pertinent factors.

(b) Each agency shall also provide opportunity for early public review of any plans or proposals for new construction in wetlands, in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require the preparation of an environmental impact statement under Section 102 (2) (C) of the National Environmental Policy Act of 1969, as amended.

Sec. 3. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in wetlands, whether the proposed action is in accord with this Order.

Sec. 4. When Federally-owned wetlands or portions of wetlands are proposed for lease, easement, right-of-way or disposal to non-Federal public or private parties, the Federal agency shall (a) reference in the conveyance those uses that are restricted under identified Federal, State or local wetlands regulations; and (b) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successor, except where prohibited by law; or (c) withhold such properties from disposal.

Sec. 5. In carrying out the activities described in Section 1 of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are:

(a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion;

(b) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

(c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses.

Sec. 6. As allowed by law, agencies shall issue or amend their existing procedures in order to comply with this Order. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order.

Sec. 7. As used in this Order:

(a) The term "agency" shall have the same meaning as the term "Executive agency" in Section 105 of Title 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in Section 1 which are located in or affecting wetlands.

(b) The term "new construction" shall include draining, dredging, channelizing, filling, diking, impounding, and related activities and any structures or facilities begun or authorized after the effective date of this Order.

(c) The term "wetlands" means those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Sec. 8. This Order does not apply to projects presently under construction, or to projects for which all of the funds have been appropriated through Fiscal Year 1977,

Attachment 18
(Cont.)

or to projects and programs for which a draft or final environmental impact statement will be filed prior to October 1, 1977. The provisions of Section 2 of this Order shall be implemented by each agency not later than October 1, 1977.

Sec. 9. Nothing in this Order shall apply to assistance provided for emergency work, essential to save lives and protect property and public health and safety, performed pursuant to Sections 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

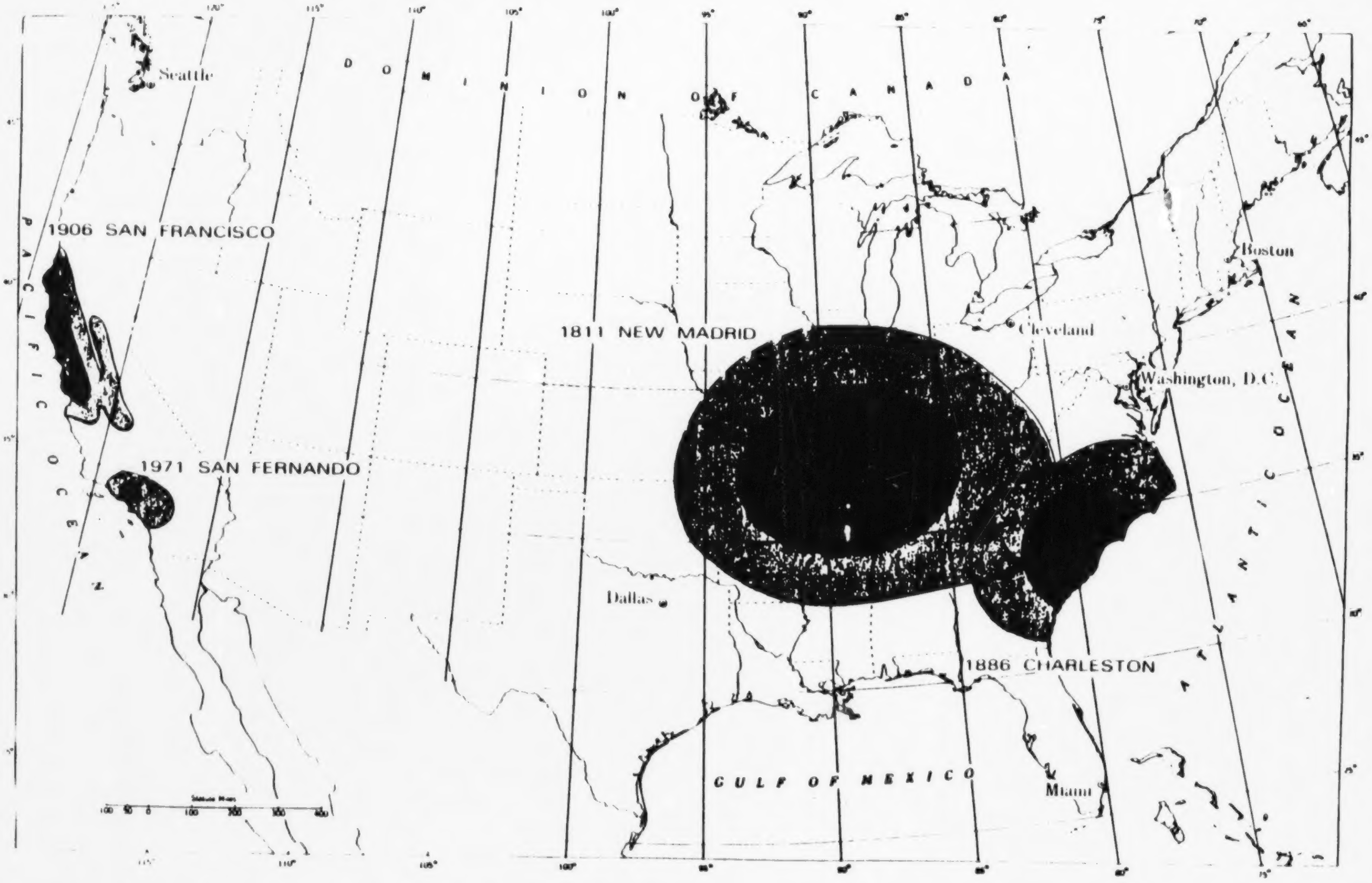
Sec. 10. To the extent the provisions of Sections 2 and 5 of this Order are applicable to projects covered by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304 (h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decision-making, and action pursuant to the National Environmental Policy Act of 1969, as amended.

/s/ Jimmy Carter

THE WHITE HOUSE,
May 24, 1977

[FR Doc. 77-15123 Filed 5-24-77; 1:44 pm]

Attachment 19
(Source: USGS, 1981)


DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
1906 SAN FRANCISCO
1971 SAN FERNANDO
1811 NEW MADRID
1886 CHARLESTON
Seattle
Boston
Cleveland
Washington, D.C.
Dallas
Miami
Statute Miles
100 50 0 100 200 300 400
120°
115°
110°
105°
100°
95°
90°
85°
80°
75°
70°
65°

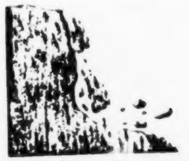
parison of isoseismal contours for a great earthquake, the 1906 San Francisco, a moderate earthquake, the 1971 San Fernando, and two large earthquakes, the 1811–12 New Madrid and 1886 Charleston. The contour lines connect sites having the same value of Modified Mercalli intensity, a numerical index of the effects of an earthquake on man, the Earth's surface, and on buildings. Each area shown in dark corresponds to an intensity of VII or greater and denotes the zone of most severe ground shaking and damage. The area lighter shade corresponds to an intensity of VI; in this area the ground shaking is felt by all, many are frightened and run outdoors but damage is slight. The effects of ground shaking extend over a much larger area in the Eastern United States.

Summary classifications and definitions of slope movements (from Varnes, 1978)

Type of movement	Type of material		
	Bedrock	Soils	
		Coarse-grained (debris)	Fine-grained (earth)
Falls	Rock fall	Debris fall	Earth fall
Topples	Rock topple	Debris topple	Earth topple
Slides	Rock-block slide	Debris-block slide	Earth-block slide
Rotational	Rock slump	Debris slump	Earth slump
Translational	Rock slide	Debris slide	Earth slide
Lateral spreads	Rock spread	Debris spread	Earth spread
Flows	Rock flow	Debris flow	Earth flow
Complex	Combination of two or more of the above		

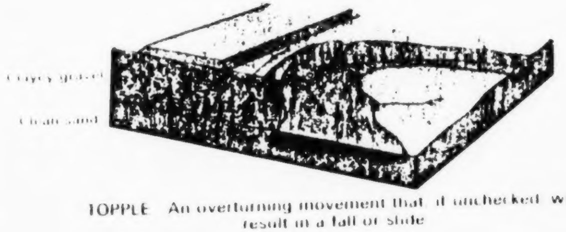
Attachment 21
(Source: USGS, 1981)

FALL (rock fall)



FALL Mass travels most of the distance in free fall, by leaps and bounds, and rolling of bedrock or soil fragments

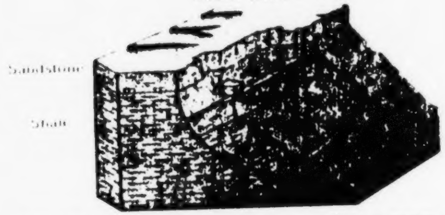
TOPPLE (debris topple)



TOPPLE An overturning movement that, if unchecked, will result in a fall or slide

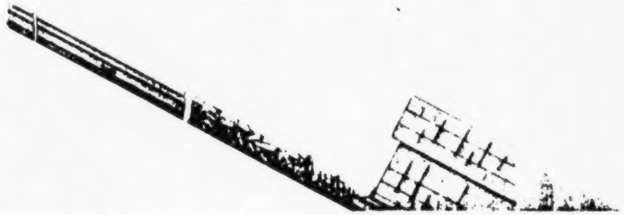
SLIDE Movement of material by shear displacement along one or more surfaces, or within a relatively narrow zone

SLIDE (rock slump)



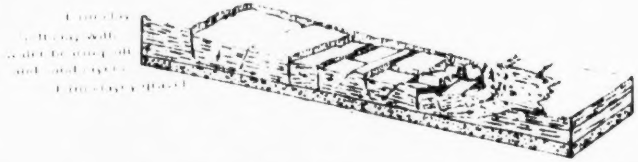
ROTATIONAL SLIDE Movement involves turning about a point (surface of rupture is concave upward)

SLIDE (rock slide)



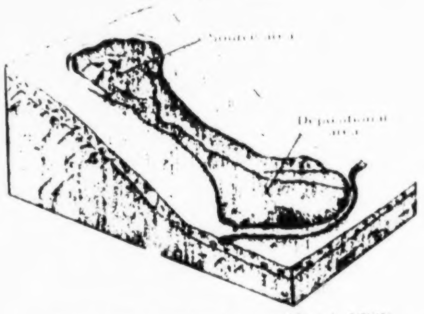
TRANSLATIONAL SLIDE Movement is predominantly along planar or gently undulatory surfaces. Movement frequently is structurally controlled by surfaces of weakness, such as faults, joints, bedding planes, and variations in shear strength between layers of bedded deposits, or by the contact between firm bedrock and underlying detritus

LATERAL SPREAD (earth spread)



LATERAL SPREAD Lateral extension movement of a fractured mass; some spreads are without a well defined basal shear surface, others include extension of rock or soil resulting from liquefaction or plastic flow of subjacent material

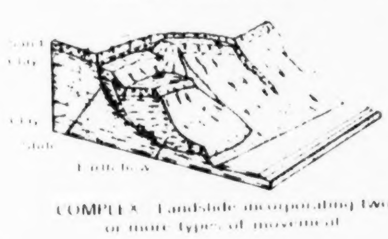
FLOW (earth flow)



(Modified from Zaruba and Mencl, 1969)

FLOW Movement of mass such that the form taken by moving material or the apparent distribution of velocities and displacements resembles that of viscous fluids; velocity ranges from slow to extremely rapid

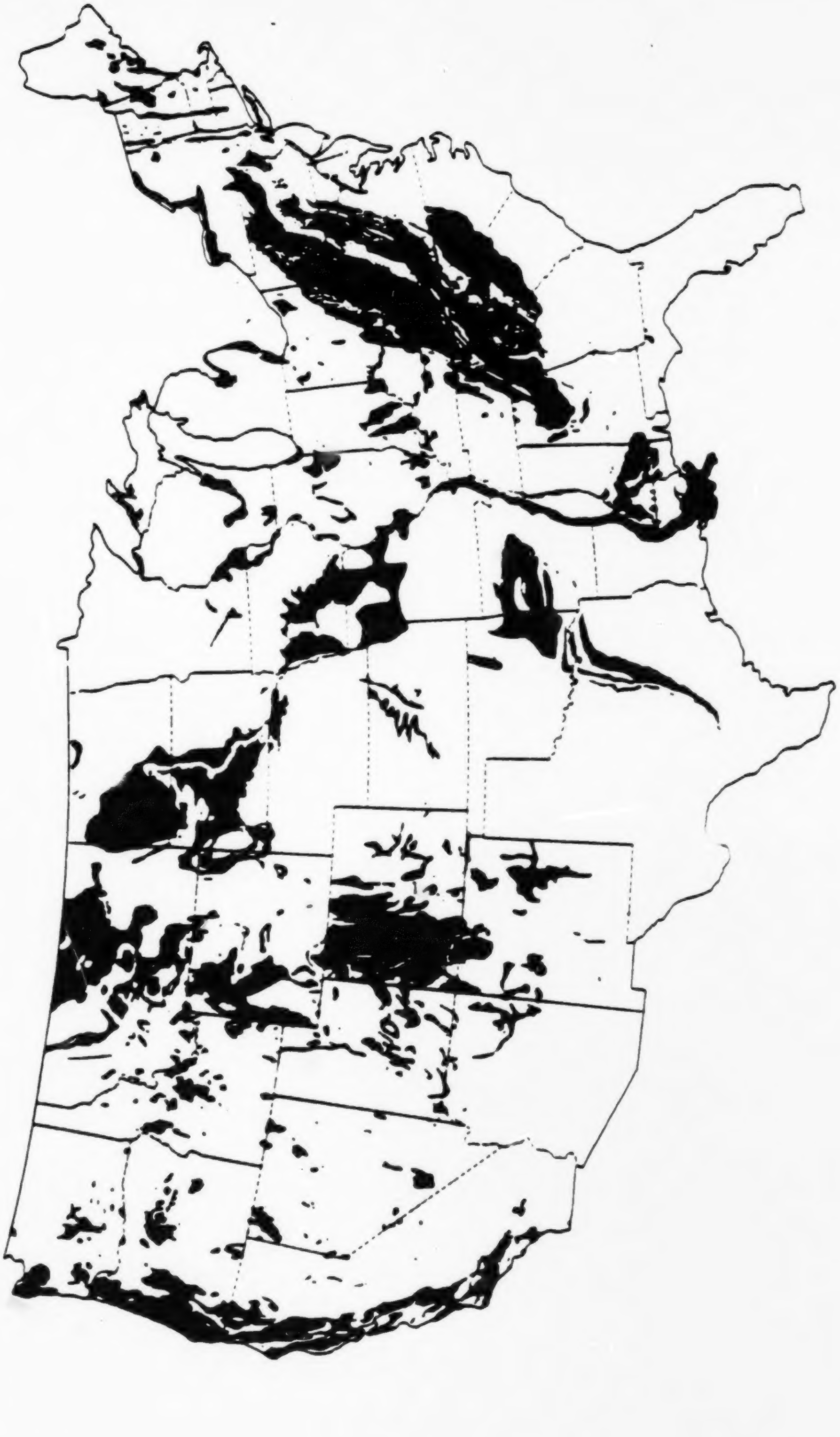
COMPLEX (slump earth flow)



COMPLEX Landslide incorporating two or more types of movement

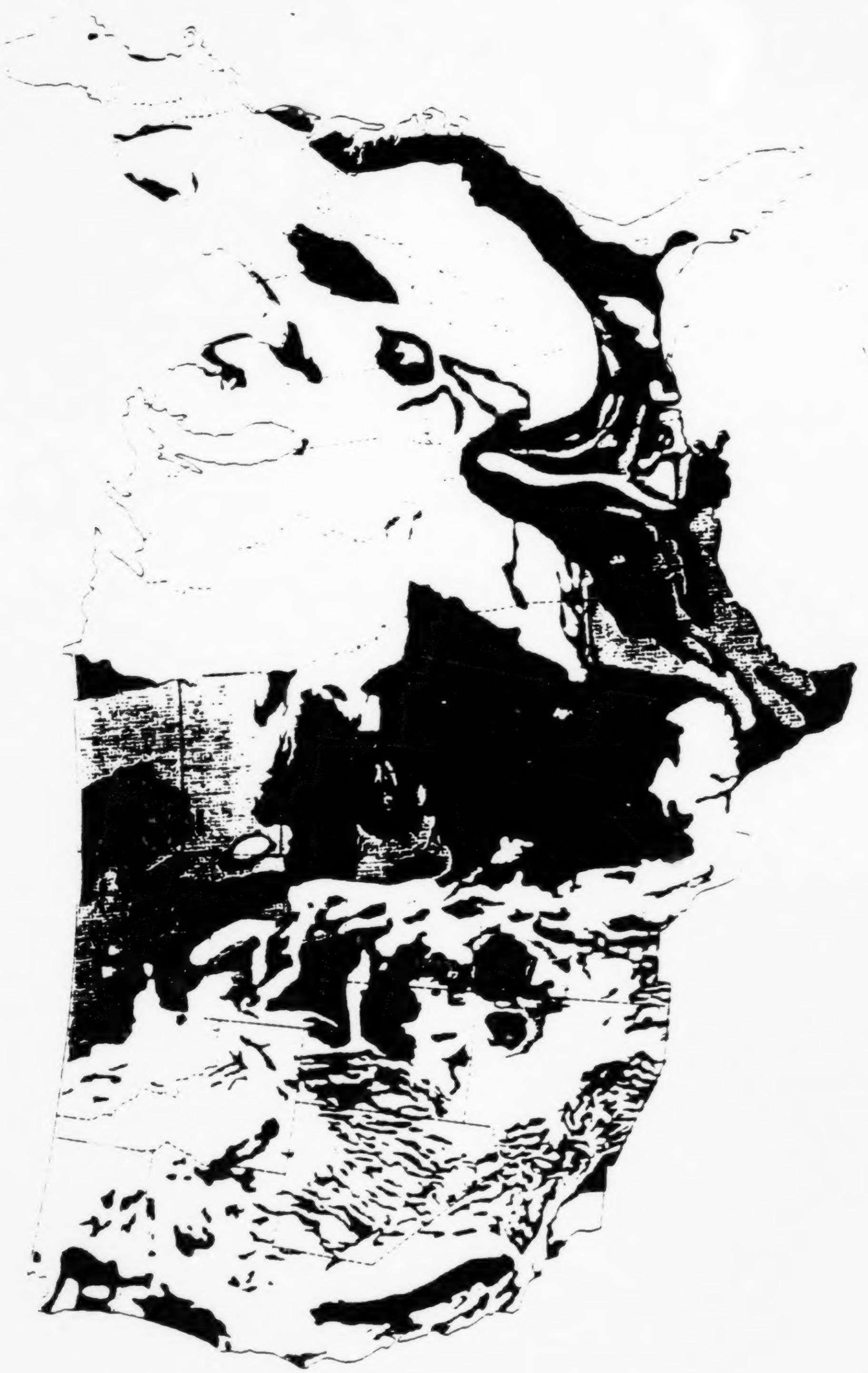
Example of Landslide
by Type of Movement

Attachment 22
(Source: USGS, 1981)



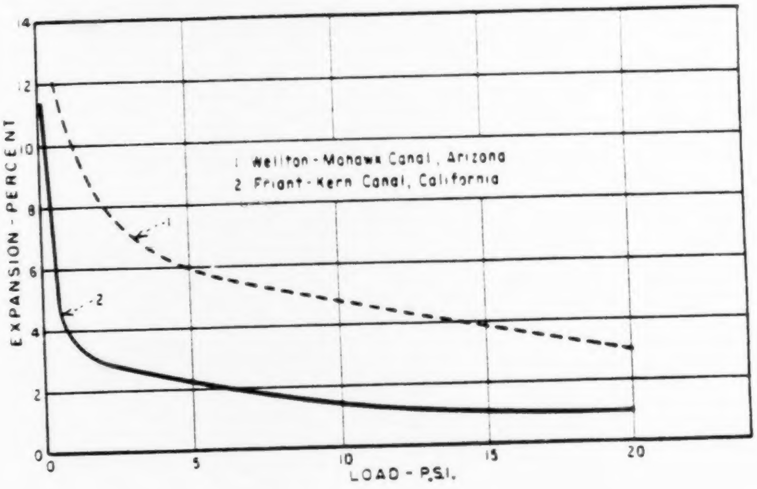
Distribution of Landslides and Landslide Prone
Areas in the Conterminous United States

Attachment 23
(Source: USGS, 1981)



Shaded Areas Show the Distribution of Expansive Soils in the Conterminous United States. Light Shading Indicates Greatest Abundance of Expansive Soils. Other Areas Exist But Are Too Small to be Shown on This Map.

Attachment 24
(Source: DOI, 1974)



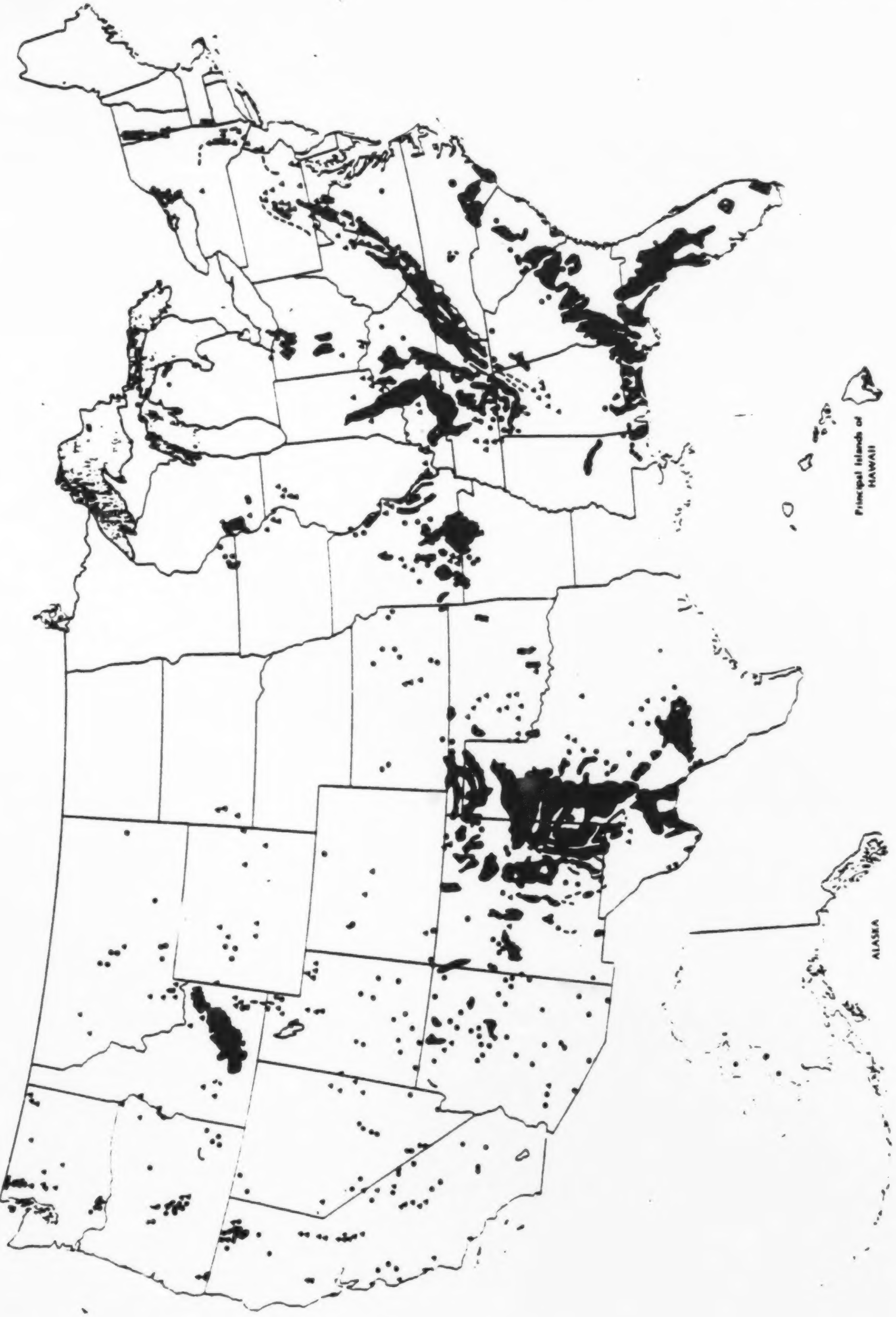
Load Expansion Curves for Two
Typical Expansive Clays

(A) SLOPE FAILURE AND BOTTOM HEAVING OF FRIANT-KERN CANAL, CALIF.

(B) HEAVING OF CANAL BOTTOM (ABOUT 1 FOOT AT CENTER) MOHAWK CANAL, ARIZ.

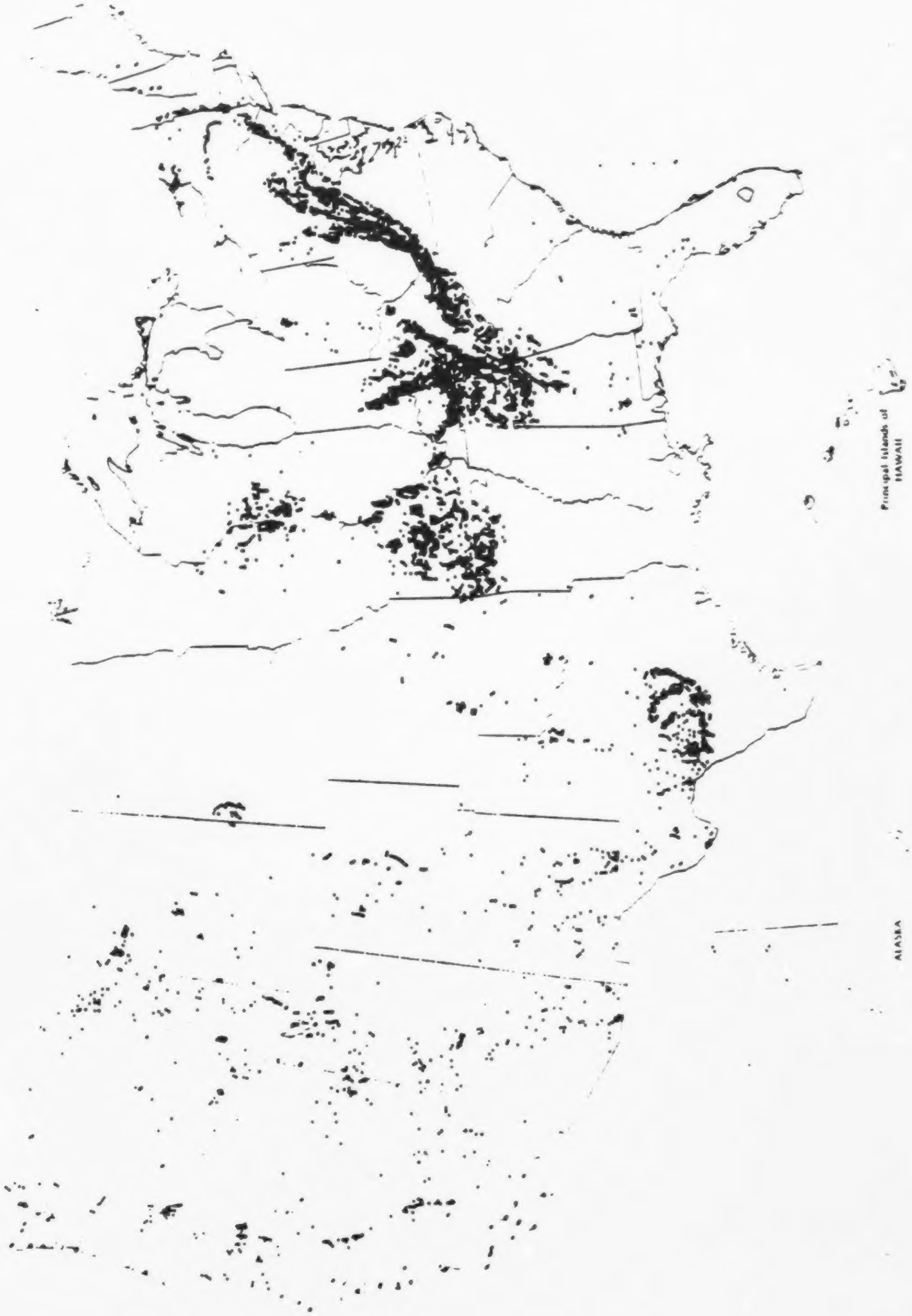
Examples of Canal Lining Failure Caused by Expansion of Clay Soils

Attachment 26
(Source: USGS, 1981)


Principal islands of HAWAII
ALASKA

Distribution of Karst Terrain

Attachment 27
(Source: USGS, 1981)


Principal Islands of HAWAII
ALASKA

Distribution of Caverns